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Making Optimal Decisions in Control the Process of a Ten-Hull Flotation Apparatus

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ABSTRACT: This article discusses the optimal decision-making in the control of the process of a ten-hull flotation apparate. Based on a computer model of a single-hull flotation apparatus, a computer model of the dynamics of a flotation complex with ten apparatus is obtained.

KEY WORDS: Technology, Enrichment, Automation, Flotation, Decisions, Optimal, Model, Computer, Apparatus.

I.INTRODUCTION

To date, the world has developed scientific foundations aimed at improving technological automated computer systems of processes and apparatus based on system thinking and analysis. Along with this, scientific research is being conducted to effectively control the composition of valuable components in the enrichment of non-ferrous metal ores, regulate the concentration of valuable components and reduce them in waste, the productive functioning of the flotation system, reduce energy costs, and minimize the content of harmful substances in technological environments [1].

The main direction in the technology of enrichment and automation of modern potash flotation plant processes is to obtain high-quality fertilizers with minimal losses of useful substances and high technical and economic indicators [2].

II. LITERATURE REVIEW

The production of fertilizers with improved physical and chemical properties is due to the needs of agriculture, the economy of production and increased demand on the world market. Therefore, improving the technology of potash ore dressing by developing and implementing more developed technological schemes, new high-performance and efficient equipment, reagent modes, and full automation of production processes is currently relevant and in demand [3]. The urgency of improving the technology of enrichment is also due to the need to develop and develop new potash deposits in Uzbekistan, Kazakhstan and Turkmenistan to produce competitive potash fertilizers to ensure their own and world markets [4]. For this purpose, a kind of indicative model of a modern potash flotation plant has been developed and proposed, linking together the advanced technologies of enrichment and process automation.

Various approaches are known for optimizing resource allocation in technological systems and production systems. The issues of optimal construction of the structure of production and technological systems are also quite developed in the relevant sciences, which consider the issues of ensuring a given performance of control systems, in particular, the so-called optimization methods of process-role systems, methods of the theory of queuing systems. The complexity of requirements for characteristics, the process of finding the structure of the production process and process control requires the introduction of a complex optimum. This formulates the task of building automated systems that provide a multi-criteria optimum [5].

The study and optimization of flotation separation are developed in three directions modeling of surface phenomena and development of reagents modes modeling of hydrodynamics of the process and development of apparatus modeling and optimization of enrichment schemes. These directions are practically not interconnected. Thus, optimization of the flow structure in the foam layer is a significant reserve for improving the flotation process indicators [6].

Using mathematical modeling methods to analyze processes at this stage with their subsequent optimization allows you to choose the optimal operating conditions and the structural scheme of the biosuspension separation subsystem. Optimization problems the most promising processes of filtration and flotation concentration of microbial suspensions are considered in [5].

Optimization of processes based on static models was carried out at several foreign factories (Tennessee, Kingsford, Anaconda, etc.). computers calculate reagent costs based on models depending on the grade of incoming ore, stabilize the pulp flow by flow rate and density, and regulate the pH and pulp level in flotation machines [11].

III. RESEARCH METHODOLOGY

Information modeling is associated with the formalization of data about the object of research. Building an information model begins with defining the goals of modeling and analyzing an object as a complex system, in which you need to highlight the properties reflected in the model and the relationships between them. Information models differ in the way information about an object is presented. Mathematical models use the language of mathematics to represent a modeling object. A separate type of statistical models is focused on processing mass data, in which there is an element of randomness. Data about the modeling object, organized in tabular form, makes up a tabular model. Graphical tools are used to build graphical models. The object-oriented approach to programming that emerged at the end of the last century gave rise to a new paradigm in information modeling: object-information modeling [7]. Computer models that reproduce the behavior of complex systems, for the description of which there is no unambiguous mathematical apparatus, are called simulation models.

IV. ANALYSIS AND RESULTS

Let's move on to a more manufacture flotation complex consisting of ten flotation aparatus.

We will search for optimal conditions for optimal regulation of an object consisting of ten apparatus - a complex of flotation of valuable products. Some enterprises that process ore containing rare and precious metals use flotation complexes consisting of ten apparatus. Based on a computer model of a single-hull flotation apparate, a computer model of the dynamics of a flotation complex with ten apparatus is obtained.

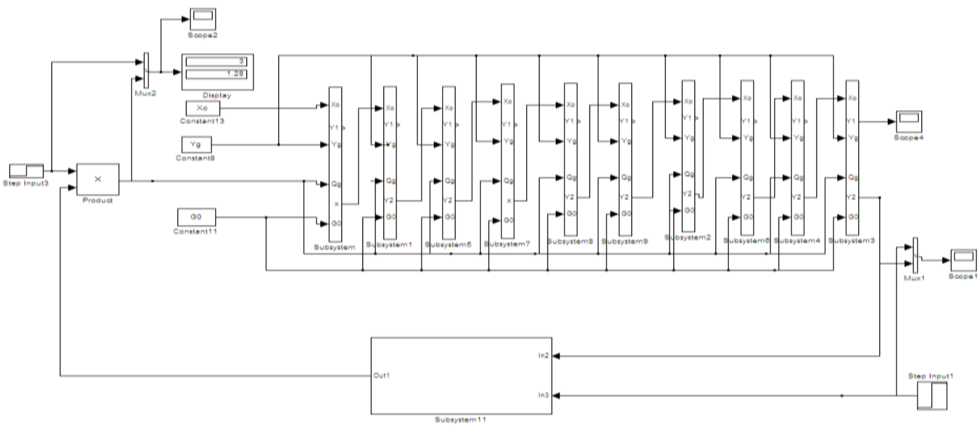

Fig1. System Optimal Regulation of a Flotation Complex, Consisting of Ten Apparatus

Figure 1 shows an optimal regulation system with a flotation complex of ten apparatus. The left part of the picture shows the decative of the flotation complex. The actuator is installed on the air supply line to the flotation setting. Measuring devices determine the possible air flow. The signal from the controller is sent to the input of the actuator.

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We search the optimal settings of pid controller with precession (gain, time ripped time and precession) involved in quality regulation of the flotation process in four-hull flotation complex[8].

The experiment reflects the regularities of changes in the concentration of valuable components in the pulp and in the gas phase.

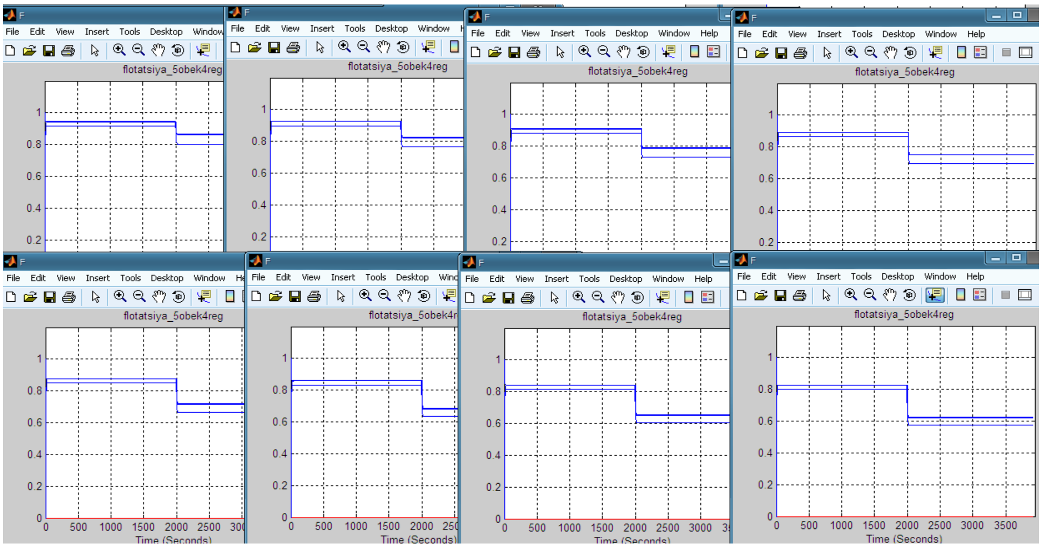

Fig2. Changes in the Concentration of Valuable Components of the Pulp in the Gas Phase (Proportional Control)

For fig. 2. shows a set diagram of the optimal control system controller, working out the proportional control mode and transition curves process. The first figure describes the output signal after the first apparatus, the second-the signal from the output of the second apparatus, and so on. Finally, the last figure reflects the change in the concentration of valuable components coming out in the pulp leaving the tenth apparatus. In order to find the optimal solution, several types of regulators were considered. For fig. 2 shows the result of the operation of the proportional controller (the components of a more general law of regulation – integral and differential-of this pid-regulation scheme were disabled). With a proportionality coefficient of 0.5, there is a normal stable transition process, but with a large static error. Such a controller cannot ensure error-free operation of the process plant system.

The set diagram of the proportional-integral controller and the transition curves of the optimal control system by a flotation complex consisting of ten apparatus are shown in fig. 3. As follows from the results of computer experiments, when the setting parameter of the proportional-integral controller is equal to 0.01, there is a noticeable improvement in the transition process from the point of view of the process dynamics [9].

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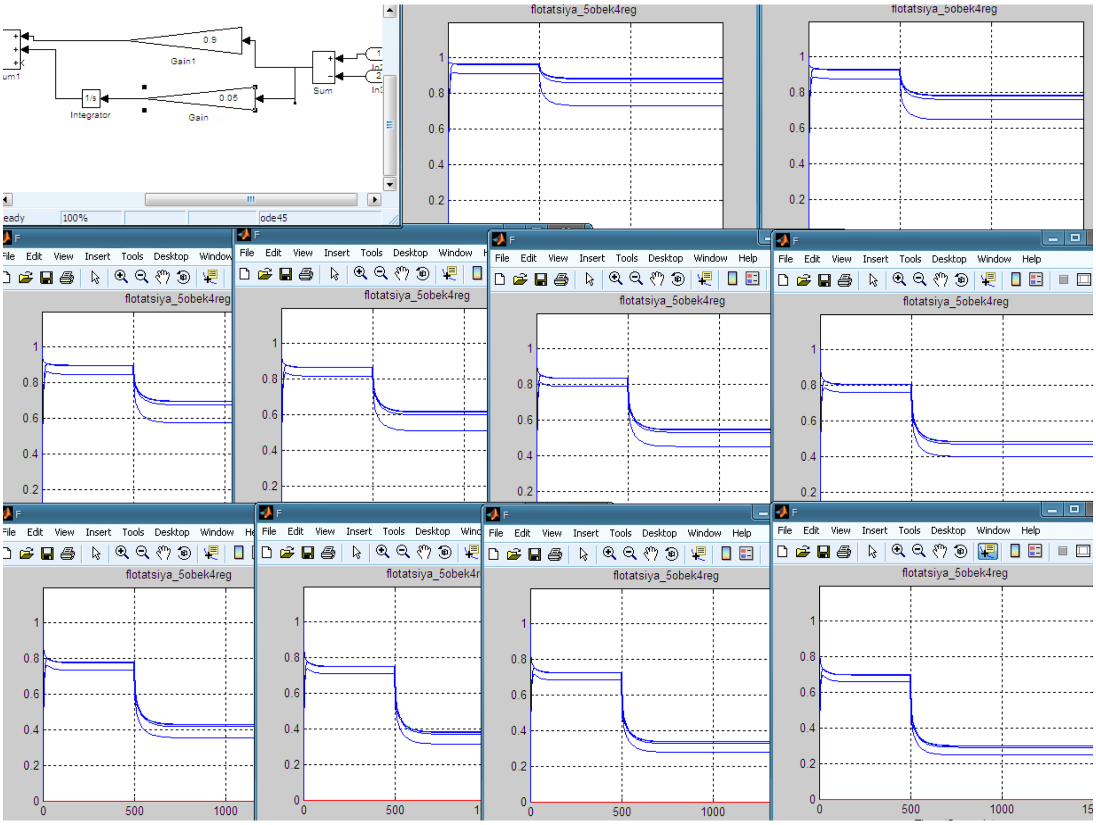

Fig3. System Optimal Regulation With Pi-Controller Flotation Complex Consisting of Ten Apparatus

Computer experiments were conducted for the case of using a proportional-integral-differential regulator.

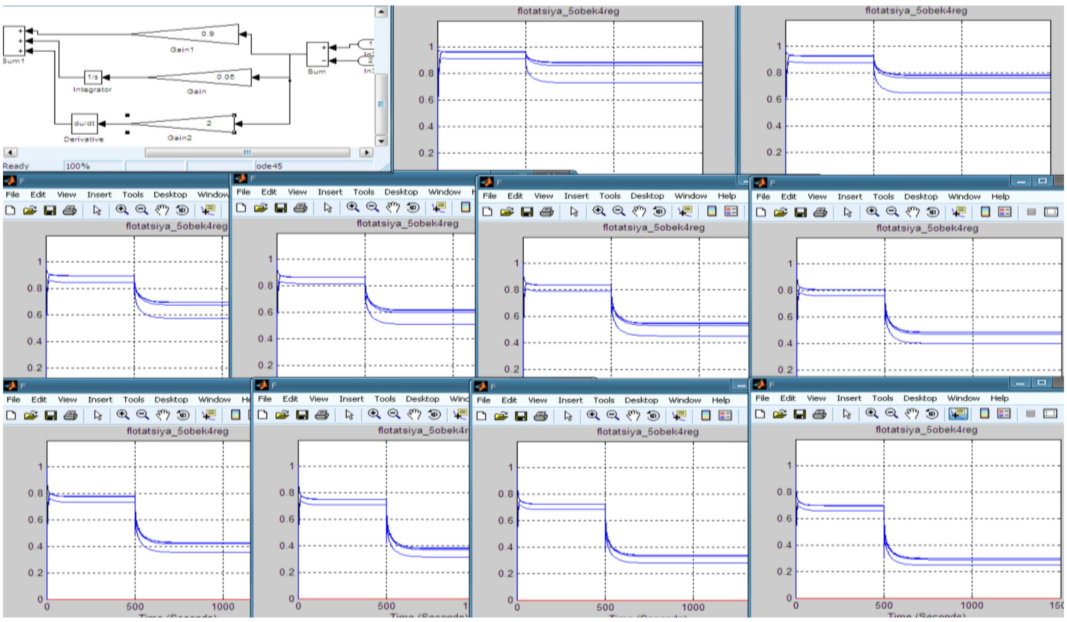

Fig4. Scheme of the Proportional-Integral-Differential Regulator and Transients in Ten Apparatus of the Ore Flotation Ores

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The search results with an attempt to use only the differential component of the control law are shown in fig. 4. It is found that the quality of transients improves somewhat, but at the same time there are step-pulse deviations in the concentration of valuable components due to the operation of the differential preliminary part of the regulator.

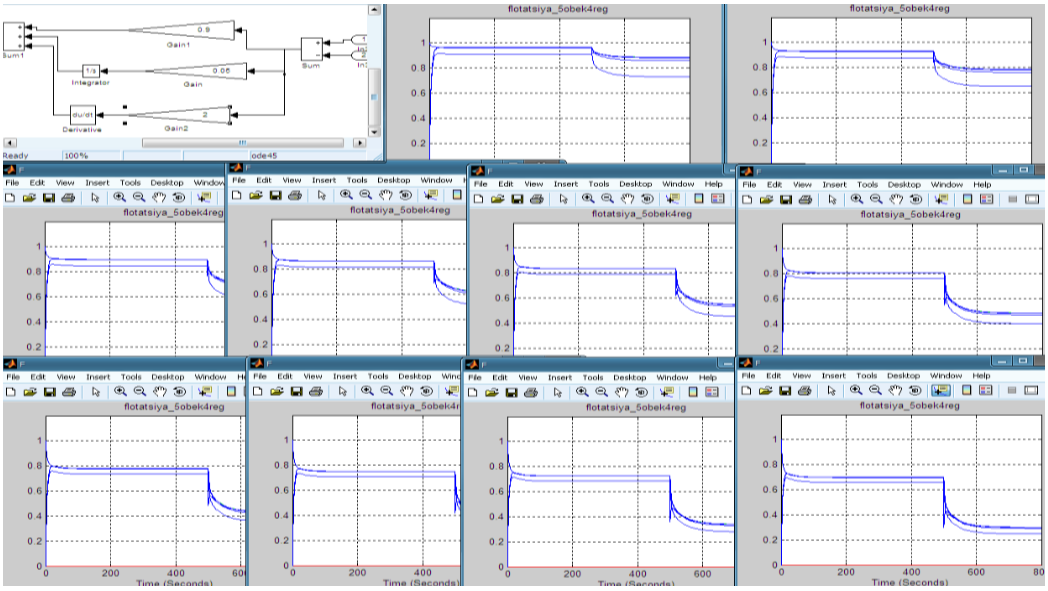

Fig5. Schemes for Optimal Regulation of the Flow of a Hardware Flotation Complex with a Proportional-Integral-Differential Regulator and Transition Curves Process at the Output of Each Apparatus.

Here, computational calculations for greater accuracy of observation were performed for the duration of a computer experiment of 800 seconds. Then repeated experiments were performed at a duration of 600 seconds. Conducting an experiment with a duration of 800 seconds corresponds to the time-the time of a certain accuracy of the transition process for the concentration of valuable components.

Then an experiment was performed when the perturbation was applied according to the computer time of 300 seconds and the duration of the process of 600 seconds, and the transient process was analyzed. Initially, at a computer time scale of 300 s. there is a relatively large transient oscillation due to the action of the differential part of the component of the control law. Then the transition process comes to a steady state.

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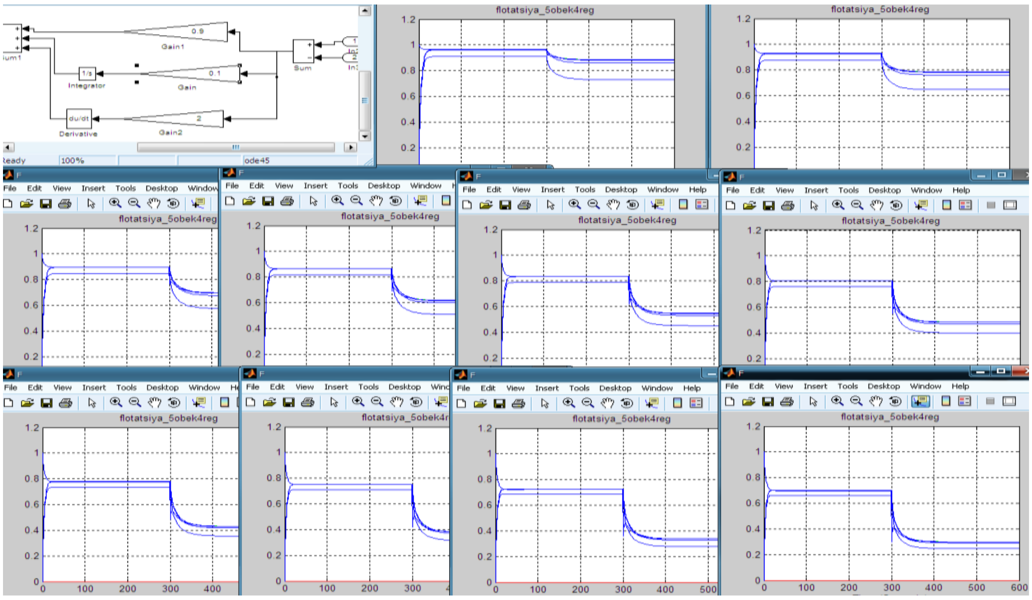

Fig6. Typesetting Scheme of the Proportional-Integral-Differential Controller and Transients after Each Flotation Apparatus of the Flotation Complex with a Duration of Computer Time of 600 Seconds and a Perturbation of 300 Seconds

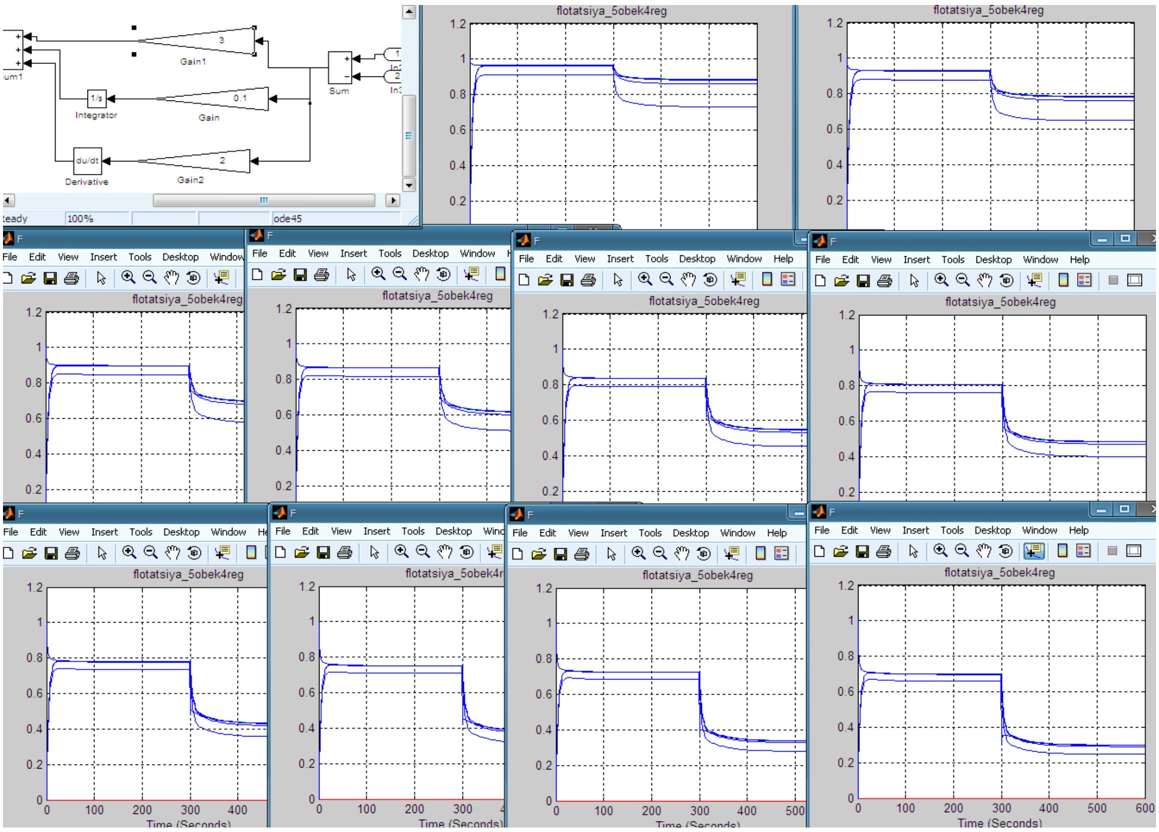

Fig7. Diagram of a Proportional-Integral-Differential Regulator with a Proportionality Coefficient Equal to 3, Transition Curves after Each Apparate for Concentrating Valuable Pulp Components in the Flotation Complex.

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As can be seen from fig. 7, the regulator with its own settings is studied: the proportionality coefficient is equal to -3; the integration coefficient is equal to -0.1; the differentiation coefficient is equal to -2.

It is shown that a change in the proportionality coefficient leads to a relative deterioration in the quality of the transition process. Therefore, experiments in the direction of reducing the proportionality coefficient of the PID regulator are presented.

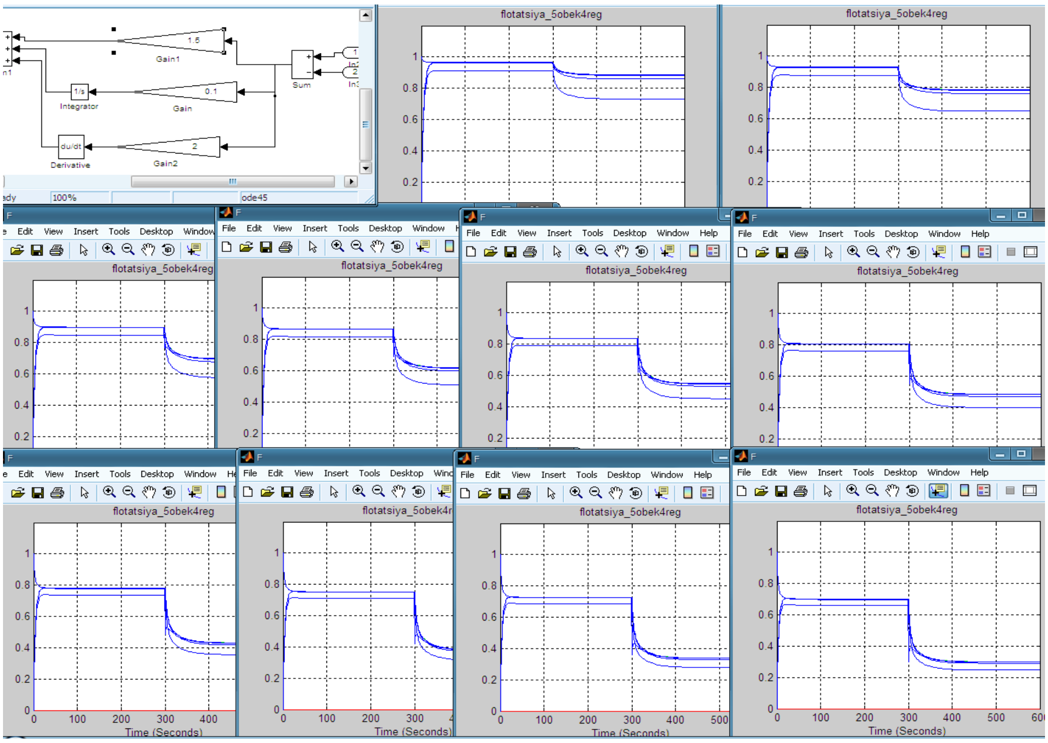

Fig8. Typesetting Scheme of the Proportional-Integral-Differential Regulator with a Proportionality Coefficient Equal to 0.5, and the Transition Curves after Each Apparatus of the Ten Apparatus Flotation Complex.

As can be seen from fig. 8, there is a noticeable improvement in the quality of transients and a decrease in the proportionality coefficient of the proportional-integral-differential regulator.

Thus, summing up the comparative analysis of the results of all computer experiments, we can conclude that the proportional-integral-differential regulator with a proportionality coefficient of 0.1, with an integration coefficient of 0.9, and a differentiation coefficient of 2 provides a positive result. Therefore, these settings parameters of PID regulators can be accepted as optimal.

Based on the conducted computational experiments, the optimal mode of operation of the flotation complex consisting of ten flotation apparatus has been identified.

V.CONCLUSION

Algorithms for calculating the mass transfer coefficient of valuable components from the liquid phase to the gas phase, coefficients of technological processes and operating modes of automated ten-hull flotation units are shown.

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