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AUTOMATION OF MONITORING IN GAS PRODUCING COMPANY

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Specific character of monitoring in gas producing company has been considered. Corporate geoinformation system «Magistral-Vostok» for controlling gas producing enterprises was suggested, the experience of this system introduction in «Vostokgasprom» was described.

Introduction

Analyzing monitoring automation problems at gas industry enterprises the problems of automation of gas-transport enterprise control services is often in focus of attention. The majority of existing both methodological and engineering solutions, hardware and software complexes and automation systems are directed to solve the problems of gas traffic control [1]. The problem of automation of gas producing enterprise control services is not less actual. Introduction of automation systems of control services allows combining data flows of enterprise various services and simplifying thereby their interaction that helps to increase as a result responsiveness of making managerial decisions and decrease expenses for achieving main planned indices.

Solving the problem of control service automation at gas producing enterprise by arrangement of executive work station (WS) in the range of geoinformation control system of «Magistral-Vostok» is considered in this paper.

Tasks of monitoring in gas producing company

As objects of production and preparation of hydrocarbon raw material (HCRM) at gas fields of one gas producing company are often in hard-to-reach areas, allocated at large territory, it is obvious that monitoring in such company should have hierarchical and multilevel structure (field executives – production service – PS; enterprise executive – central production service – CPS).

The task of PS executive is to support fulfilling the plan in production, preparation and transportation of HCRM to supply pipelines in conditions of constraints which are imposed by:

- *geological survey* – planned and real levels of HCRM production;
- *production development* – capacity of complexes for HCRM recycling (devices for complex preparation, gas recycling, devices of downhole condensate de-ethanization);
- *control services of adjacent oil- and gas-transport enterprises* – pressure corridors which should be kept at supply pipeline inputs.

CPS executives ensure providing all production units, top management, control services of oil-and gas-transport enterprises (OGTE) as well as higher institutions (for example, «Gasprom») with aggregate proces-

sed information about production current state. For this purpose CPS should be provided promptly and continuously with sufficient volume of original (from technological process automated control systems TP ACS and units of HCRM accounting) with aggregated and rated information from all field PS.

Main stages of planning production indices and forming production reporting (reports and summaries) by actual data in gas producing company are given in Fig. 1. Enterprise production development forms annually a plan of production, preparation and delivery of gas and condensate (oil) which determines enterprise performance per year. The main indices of production by fields and deposits are determined in the plan, commercial and freak costs of HCRM as well as delivery indices by consumers are forecasted.

«Annual plan of production, preparation and delivery of gas and condensate» together with live data about development obtained from «Control list» is the base for monthly formation of «Operating practices of well performance» by geological survey which determines mode of operation of each well at deposit obligatory for keeping during the month for achieving the specified flow rates of HCRM.

On the basis of these plans and actual data (summaries) from all PS fields in CPS the report «Control list» which contains aggregated information about fulfilling the plan in HCRM production, preparation and delivery is daily formed. The report also contains information about field operations, well shutoff, HCRM loss, unit modes of operation, pressures, temperatures, consumptions and power inputs at the main production units. A part of the data of «Control list» characterizes the whole day and another one is completed within every two hours and it allows estimating dynamics of the process during the previous day.

Daily plan is the task for executives of PS fields (deposits) where monitoring of equipment state in real time and operational control of HCRM production and preparation occur for achieving specified daily planned indices. Every two hours PS executives gather information from different field services of the enterprise for example chemical laboratories, geological survey, etc., which is transmitted to CPS together with a part of machining information from TPACS required at high level of management.

Problems of production service automation

The given cycle of data collection and information interchange between control services and other participants of production activity may be realized in the range of distributed automated production control system that is the system of MES (*Manufacturing Execution System*) type. Such system introduction allows combining data flows of different production services of enterprise and simplifying thereby their interaction that helps also to increase the responsiveness of making managerial decisions. This very system should contain subsystems allowing automating activity of production services occupying central position among production associations of gas producing company. MES-system position in information space of gas producing enterprise is given in a generalized view in Fig. 1.

This system in a general case exchanges data with the mentioned field TPACS, OGTE information systems and control system of Central production depart-

ment (CPD) of «Gasprom» or control system of another superior institution. Besides, MES should be integrated in data with ERP-system of enterprise (automates business-processes of a company) and BI-system (*Business Intelligence*) intended for deep analysis of financial-economical and production information. It should be noted that the additional advantage of MES introduction is a possibility of using the whole complex of production-machining and other information for solving the problems of optimization (often solved in the range of BI-systems) that allows decreasing expenses for achieving the main planned production indices.

In our opinion, the following factors influence the processes of development and introduction of MES for gas producing enterprise allowing automating control service performance. First of all, the fact that at certain stages of production process the heterogeneous automation facilities which form data being a base for making decisions by executives of different levels are often used

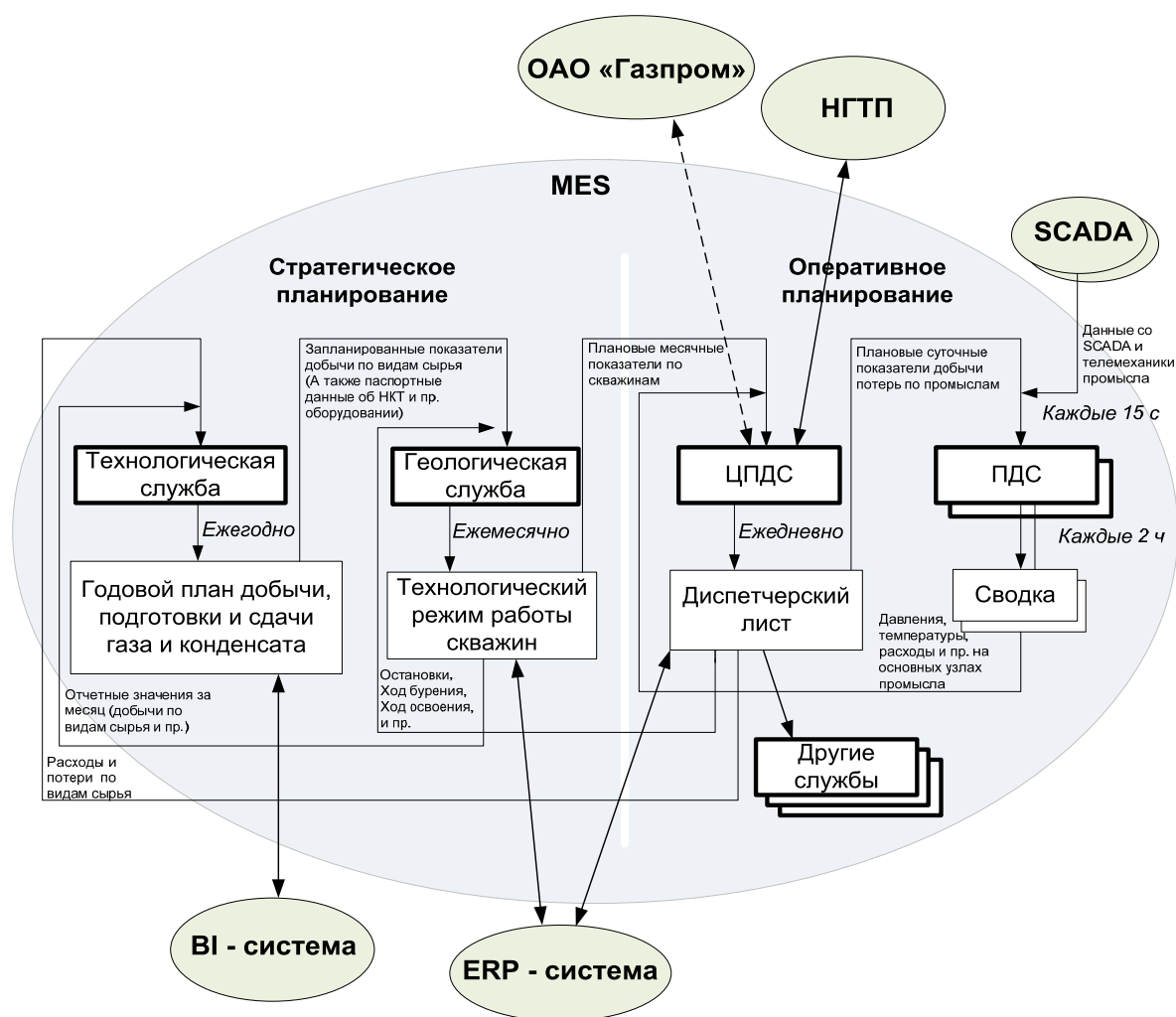


Fig. 1. MES place in information space of gas producing enterprise
 ОАО «Газпром» – «Gasprom»; НГТП – OGTE; Стратегическое планирование – Strategy planning; Оперативное планирование – Operational planning; Технологическая служба – Production development; Геологическая служба – Geological survey; ЦПДС – CPS; ПДС – PS; Годовой план добычи, подготовки и сдачи газа и конденсата – Annual plan of production, preparation and delivery of gas and condensate; Технологический режим работы скважин – Operating practices of well performance; Диспетчерский лист – Control list; Сводка – Summary; Другие службы – Other services

may be considered as the factor complicating MES development and introduction [2]. A part of these facilities functions in the range of close technological computer networks having no input into enterprise office networks. Therefore, solving the problem of integrating data and functions of heterogeneous automation facilities existing at the enterprise being possible for executive access to them in the range of enterprise uniform information system including remote working places is actual. The next factor is low executive experience in the field of information technologies. System users are specialists in their knowledge domain and possess limited knowledge of the field of information technologies which are reduced as a rule to elementary skills of using office software (text editor, spreadsheet, mail client, web browser). As a result, the introduced system should have simpler user interface. The compulsory condition of successful introduction is user training and it is desirable that with further testing. If these factors are not taken into account then a number of technical-organizational problems occurs at MES introduction.

There are problems of connecting TP ACS to MES. The fact is that the data from TP ACS are transmitted to consumers of these data through moderators presented by executives without control service automation (Fig. 2).

In this case the data undergo many changes such as unit transformation, refinement etc. Besides, these data are transferred by a chain: from concrete specialist of one or another production field service through the executive of PS to CPS executive and may undergo updating in this

case. It often occurs so that nobody in this chain knows the whole algorithm of obtaining concrete index. Therefore automating control services at the first stage it is necessary to construct the system in which a man is a moderator between TP ACS and the system itself. Dropping such system step-by-step to lower levels of monitoring it is necessary to exclude more people from the chain exchanging them by direct channels of data from TP ACS till amount of people comes to the least possible value. In this case it is necessary to remember that probability of man interference into data flow for its updating in cases when one or another TP ACS in a certain moment does not give valid values of these data should be always provided in the system. It is necessary to remember about the problem of original data introduction. It is necessary to introduce original data for the implemented system to start really operate: to fill in manuals; introduce data for the previous periods etc. Specialists of control services where the system is introduced are weakly motivated for fulfilling this work. Therefore the optimal variant is to introduce this information by introduction team.

Executive WS in the system «Magistral-Vostok»

Enterprise geoinformation system for controlling production of gas-producing company (then EGCC «Magistral-Vostok») was developed by the institute «Cybernetic center» at Tomsk Polytechnic University. It is intended for automation of activity of different manufacturing services of enterprise and taking into account its features is MES [3].

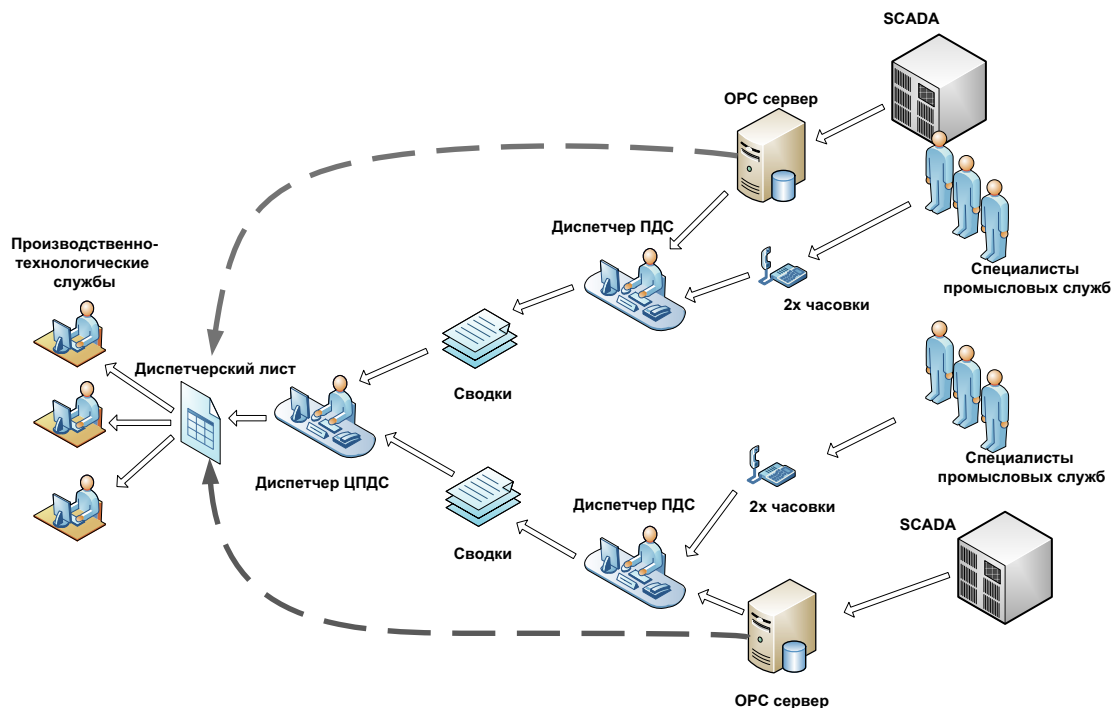


Fig. 2. Stages of automation of the processes of obtaining data from TP ACS: \leftarrow is the path of data at the first automation stage; \leftarrow is the path of data at the final stage

Производственно-технологические службы – Production-engineering services; Диспетчер ПДС – PS executive; Специалисты промышленных служб – Field service specialists; 2x часовки – 2 hours; Сводки – Bulletins; Диспетчерский лист – Control list; Диспетчер ЦПДС – CPS executive; OPC сервер – OPC server

This system allows automating solution of the following tasks:

- obtaining industrial-engineering information characterizing deposit operation conditions, production equipment mode of operation, HCRM preparation and transportation;
- sampling the most efficient operation modes of the objects described before;
- accounting (categorization) of processing equipment;
- planning and controlling performance of planned seasonal, preventive, verifying, repair and other works of production and engineering character;
- making solution in emergencies.

Let us consider in detail some features of EGCC «Magistral-Vostok» architecture. Operation of this system is not possible without processing and delivering information came from lower levels of enterprise management and first of all from gas fields (deposits). The uniform data bank based on industrial DBMS Microsoft SQL Server 2000 was developed for this purpose. The unified structure of data bases (DB) of nominal, planned, manufacturing, cartographic and processing information was designed and implemented.

The problem of unification of data acquisition system about processing from different outer TP ACS by protocol of OPC (OLE for Process Control) the support of which is the standard for such kind of systems was solved.

Structure of EGCC Структура КГСУ «Magistral-Vostok» is multilevel and hierarchical repeating enterprise organizational structure: enterprise level – subdivision (field) level – department (deposit) level.

Each control system excluding enterprise level is connected with higher system and it may also have one or more slave systems. In the range of existing bonds control systems exchange information. In this connection system DB has a distributed structure supported by random number of independent servers.

A built in facilities of data replication MS SQL Server 2000 and its tree-component model: editor – distributor – subscriber, are used as a basic mechanism of data exchange between servers of system different levels and one level servers [4]. Due to its heterogeneity and multidirectivity the whole information content which is used in system server exchange may be divided into several flows: nominal information, technological information, planned information, production information, cartographic information. To transmit each flow its own replication mechanism is used with possibility of its flexible adjustment by system administrator.

System users interact with it by a number of work stations constructed by modular approach and having unified interface. System kernel is implemented so that work station of a concrete user may be formed from random module (subsystem) set realizing its one or other functions.

At present the system consists of 10 subsystems; there are developed instruments for its adapting to peculiarities of a concrete gas-producing enterprise [4].

To support the process of monitoring gas-producing enterprise EGCC «Magistral-Vostok» includes executive workstation of production services of different levels. And automatic data exchange is supported both between management different levels (deposit PS – field PS – enterprise CPS) and in the range of one level services. Besides, information path support with outer control systems, for example, CPS «Gasprom» or CS of OGTE is possible.

Workstation includes subsystems of production planning, formation of control list and manual input forms, visualization of industrial information and trends, symbolic circuits and flow diagrams, cartographic subsystem, subsystem of event journaling, equipment categorization, designing reports etc. Let us consider in detail features of the main subsystems.

Production planning subsystem allows forming plans of procedures and works, production indices, including those on basis of previous plans, controlling their performance, searching and scanning planned information.

Subsystem of forming control list and manual input allows forming and scanning tables containing the most important production indices characterizing enterprise performance in convenient and usual way for executive.

Subsystem of visualization of technical process symbolic circuits allows the executive to control production promptly (first of all the process of preparing gas and gas condensate) in the most convenient way – by graphic symbolic circuits, changing dynamically at operational data entry (Fig. 3).

Subsystem of maps and process flowsheet visualization. The subsystem is intended for supporting scanning functions of digital maps and off-scale process flowsheet.

Subsystem of visualization of industrial information and trends. The subsystem implements the following main groups of functions:

- scanning the list of process variables in which their main attributes, classification and filtration of display list are imaged;
- scanning additional attributes of concrete variables;
- scanning the trace of variable change in tabular and graphic form (process variable trends) within the period selected by a user;
- tracing the change of process variable values in tabular and graphic forms in real time mode.

A set of vector or raster maps of various scales as well as off-scale process flowsheets arranged in DB is available for users. Subsystem graphics kernel is GIS – library MapInfo MapX 4.0 that allows using wide set of vector maps of a popular format MapInfo.

With the help of this subsystem the executive can solve the problems of isolating emergency sections, tracking emergency crew etc.

Subsystem of event journaling. The following functions are implemented:

- signaling at emergency;
- visualization of a list of important events or emergencies and moments of their occurrence;

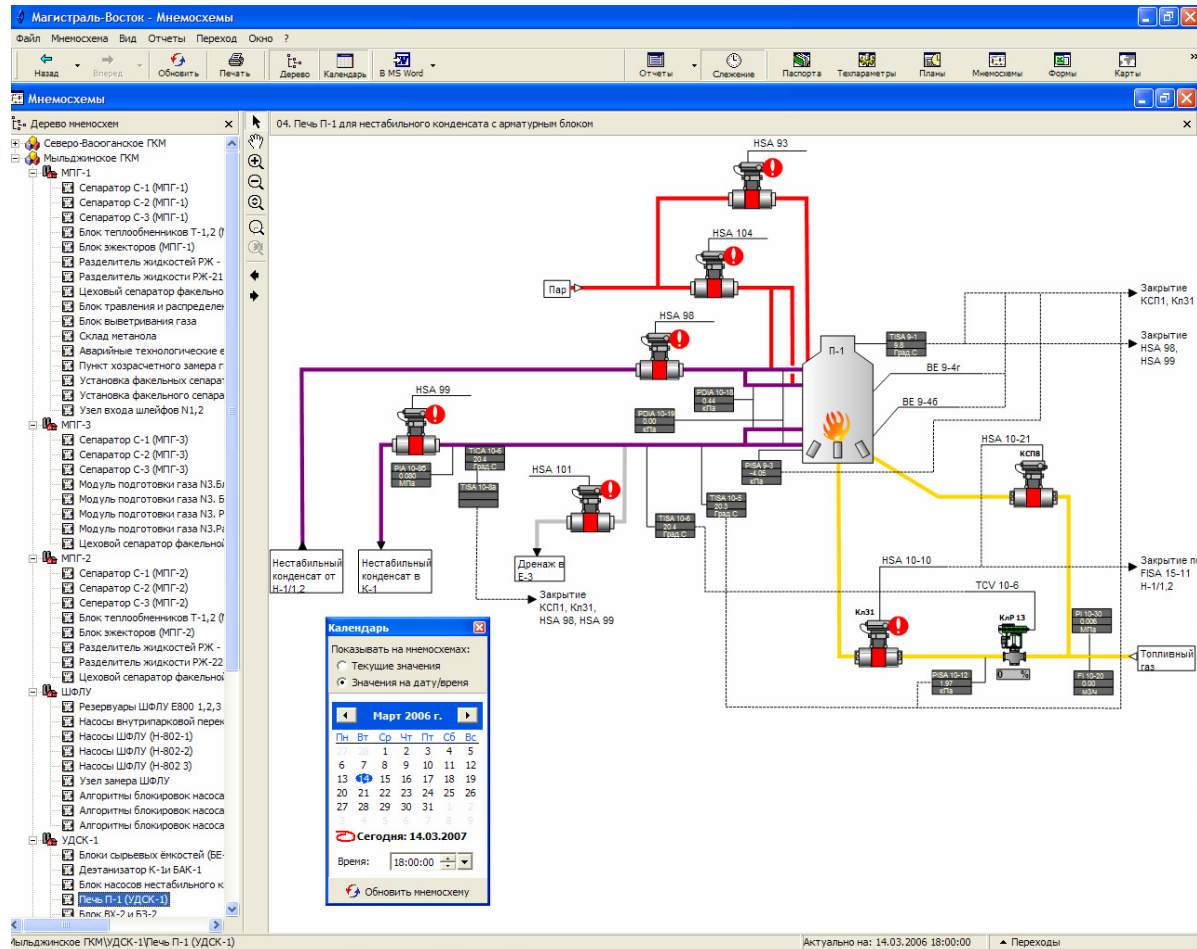


Fig. 3. Subsystem of symbolic circuit visualization

- message exchange between control services of different levels.

Subsystem of designing reports and manual input forms.

This subsystem possesses the following main features:

- development of new types of reports and manual input forms and change of the existing ones without changing anything in existing software;
- report immediate print by means of subsystem itself;
- export of the developed reports into format consistent with Microsoft Office.

Conclusion

At present the majority of control services of gas-producing enterprises have low level of automation that results in excess costs for keeping highly skilled specialists, unappropriateness of resource consumption at selection of equipment operation mode, uncertainty of data transferred between industrial services of gas-producing enterprise etc.

The existing solutions in the field of control service automation in gas-producing branch are usually developed both owing to expansion of TP ACS functions and owing to expansion of ERP-system functions. Modern researchers in the field of information technologies separate a single class of MES for solving the tasks of controlling production and its monitoring in particular. MES theory is rather young and it is at the stage of rapid development therefore, there are practically no mature solutions at the moment in Russia.

Enterprise geoinformation system «Magistral-Vostok» developed in the Institute «Cybernetic Center» at TPU is a valid MES supporting functionally the newest standard ISA S95 «Enterprise-Control System Integration» [5]. In the range of this system the executive work station including several subsystems and solving fully the problem of automation of all level control services in gas-producing enterprise was developed. The developed software was successfully introduced at all work places of executives of field PS and CPS «Tomskgasprom».

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AUTOMATED CONTROL SYSTEM OF EXTRACTION COLUMN

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Extraction column has been analyzed as a control object; its mathematical description has been developed subject to the peculiarities of processing. On the basis of mathematical description the simulation model of column device was developed. Automated control system was synthesized by re-extract density in pulse column. Estimation of control quality supported by the system was carried out.

Extraction technologies were widely adopted in radiochemical industry; their use allows supporting substance separation. Pulse column extractors connected step-by-step are used in reject fuel processing for hardware design of these technologies.

To decrease production costs, increase safety and change elemental base of controlling means in the devices for processing spent fuel (SF) the task of development of automated control system (ACS) of re-extraction process in extraction column, being a part of the device, was set.

In papers [1–3] extraction process modeling in column devices is examined, however, the results obtained their do not allow developing the efficient automated control system. The models developed before contain simplified differential equations the solutions of which do not support the required accuracy of process modeling.

Scientific novelty of this paper is in development of extraction column model as a control object that allows designing automated control systems operating in real time. Installation of automated control system at extraction column is a new engineering solution as well. Development of qualitative automated control system by re-extraction process allows increasing its safety, improving production engineering-and-economical performance.

The studied object (Fig. 1) represents the unique device for irradiated fuel processing by extraction technique [4] it includes 5 extraction plate-type pulse columns (EC).

The head extraction column EC1 is intended for uranium and plutonium extraction and wash-out of fission products from organic phase by descending current of nitro-acid water solution. Further extract washing occurs in column EC2 for removing highly active fission products and uranium and plutonium re-extraction occurs in EC3 and EC4. Column EC5 is intended for extractant washing.

Water flow – WF (continuous phase) and organic phase flow – OP (dispersed phase) enter the column EC4. WP flow is supplied by a pump and its consumption is controlled by local stabilization circuit. Water phase is extracted from lower sedimentation zone of EC4 by a built up pulse pump in the form of uranium re-extract. Pressure in receiver is stabilized by a local circuit by a valve.

EC4 column operation in manual mode implies increasing agent expenses. At excess inflow of water phase the expensive organic phase may be removed to re-extract with water phase. Otherwise, at deficient inflow of water phase metal goes into extractant. Stabilization of organic phase density and therefore, uranium concentration at specified level allows decreasing economic losses. This very fact stipulates the choice of EC4 column as a control object for the developed automated control system.

Examining the cascade as a whole it is seen that consumption of OP flow influences the technological processes in all columns therefore it can not be considered as a control action for EC4. It can not be used as a control one therefore, change of water phase consumption is chosen for control.