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DEVELOPMENT OF METHODOLOGICAL PRINCIPLES IMPROVING QUALITY OF RESEARCH ORGANIZATION IN SCIENTIFIC AND PRODUCTION ENTERPRISES

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Abstract

Comprehensive analysis of activities of a research and production enterprise was performed, and the most effective areas were identified. Techniques and methods of effective management decisions are provided, taking into account specifics of the scientific activity, as well as the method for simulating the process of creating innovations to quantify the state of ideas and forecast for the future. A mathematical model is proposed for predicting parameters characterizing the full life cycle of ideas implementation. Main characteristics of the model and their alteration at various stages of the idea life cycle are described. An approach to solving the problem of intellectualization in the scientific and production enterprise workflow is outlined, and within its framework a technique for automatic analysis of the text of documents and its meaningful indexing is proposed. System application in solving the problems of scientific research in the NPO "Lakokraspokrytie" from planning to implementation is demonstrated. Organization of operations using an intelligent scientific research management system and making the right strategic decisions makes it possible to increase the enterprise economic performance indicators

Keywords

Management, scientific research, simulation, life cycle, intelligent document workflow, production organization

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Introduction. Analysis of data on technological position of the Russian economy separate areas in the non-financial sector reveals the necessity to technologically re-equipment almost the entire industry [1, 2]. For example, in chemistry and petrochemistry, where the progress in industrial development was mostly noticeable recently, significant drawbacks at the existing enterprises organization and technology structures were identified. In particular, specific energy consumption per a product unit of domestic enterprises is 1.5–2 times higher than that of the foreign enterprises. Similar situation is observed in many sectors, including the paint and varnish industry. Thus, interests of the domestic industry require to take measures aimed at stabilizing within the science-intensive technological complex and creating conditions for its sustainable development, which could not be achieved without preliminary reformation of the existing structure of the economy real sector.

The most important applied science-intensive technologies could include technologies of intersectoral in nature creating significant prerequisites for development of various technological areas and, in aggregate, making the main contribution to solve key problems in implementing the state scientific and industrial policy.

Operation of scientific and production enterprises (SPE) and their prospects should be forecasted even at the stage of evaluating the innovative project efficiency, i.e., at the design stage. Moreover, when commercializing technologies, it becomes necessary to assess not only market conditions, where the proposed products would be introduced, but also creation of a competitive flexible technology for its production, which makes it possible under the altering market situation to quickly re-profile it to another, more promising similar model.

Business size, its presence in most countries of the world and its level of cost are the important factors for success in the market, but innovations, research and development (R&D) are remaining the key factors. On average, R&D costs for manufacturers amount to 3–5 % of the revenue.

Research is aimed at finding new types of products, as well as new areas of application for the existing types of products, which allows enterprises to increase sales, profits and create barriers to market entry for the other participants.

Operation and development prospects of the enterprise and of the industry as a whole depend on implementing the R&D results. This is facilitated by the organization effective systems, forecasting and management of the enterprise scientific research.

Complexity of organizational structures and diversity of processes associated with R&D practices generate duplication of information flows, makes it difficult for co-executors of scientific work to interact with each other and with customers; and there appear time delays at the stages of planning and analyzing the research activities. On the other hand, the processes of an enterprise research activities management are subject to flexibility and efficiency requirements to develop prompt management decisions. To remove these restrictions, new approaches to technologies in managing research activities are required to be developed.

Financial relations permeate all areas of the SPE activities: scientific research and testing: relations with third-party enterprises and organizations in supplying materials, components, services; relations with the banking system in settlement and loan and debt services; relations with branches and subsidiaries; relations with tax service and audit firms; relations with the enterprise employees in regard to salary payment, etc. [3–5].

A common feature for all types of relations is that they are expressed in the monetary form and arise as a result of certain business relations [6]. Therefore, the state of financial relations or the state of a SPE finances is determined by the state of its scientific activity. And vice versa, rational financial structure is the factor for ensuring successful scientific activity.

SPE business comprehensive analysis. Main tasks of an enterprise comprehensive analysis include [7–10]: studying general research trends and areas; comprehensive assessment of the accumulated scientific and technical potential; substantiation of planned targets and formation of a plan in accordance with the accumulated potential; identification of internal reserves and determination of the most effective measures for their implementation. At the same time, joint thematic and financial analysis of the research activities are the most effective in solving these problems (Fig. 1).

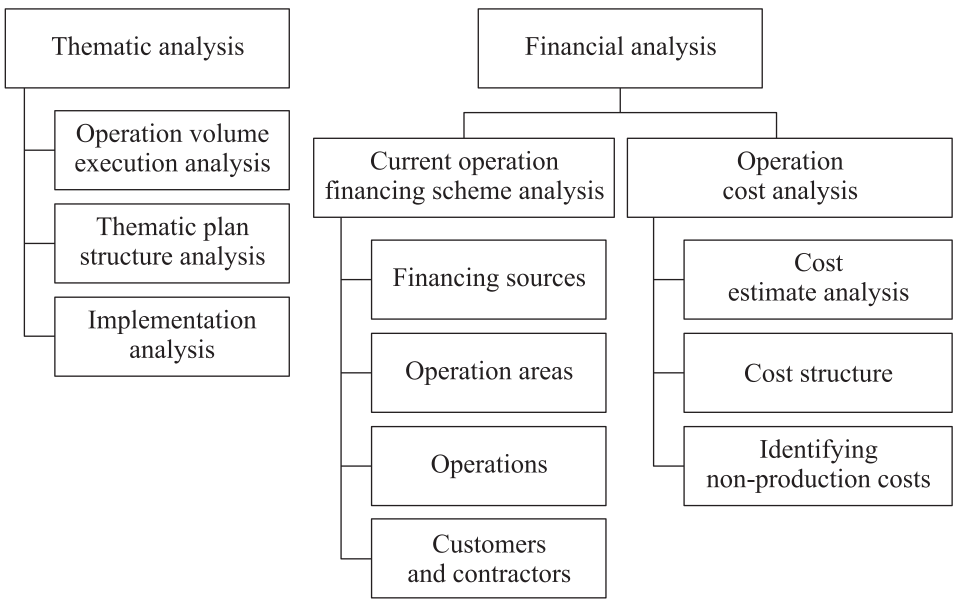

Fig. 1. Research analysis areas

Degree of plan implementation is assessed in terms of its volume, composition and timing of scientific work within the thematic analysis.

To characterize works in terms of volume, indicators of annual total volume of work using the owned resources, operation start and end dates are used [5]. Currently, scientific works in terms of their value are accounted for at the contract price and cost used to determine the work scope.

Thematic plan structure analysis consists of studying the ratio of works differing in various essential features [11]. These include R&D type, its intended purpose, resulting products and research object. Specific ratio between works is calculated by their number and volume in the value terms.

The task of analyzing the development implementation consists of studying volume, scale and timing of the competed work result practical use. Such an analysis includes determination of the need for implementation, actual implementation by years, economic effect obtained, as well as the reasons for not implementing.

While thematic analysis is aimed at obtaining the most general characteristics of scientific activity for making strategic decisions, financial analysis is used in operational management and allows for a more detailed assessment of the SPE operation. Financial analysis is performed in order to rationally allocate financial resources.

Main analysis areas include analysis of the SPE current operations financing system and costs for creating scientific and technical products aimed at identifying the cost of work reserves.

Costs composition and structure in terms of economic costs and calculation articles are considered in the analysis, irrational costs are identified, and ways are found to reduce costs to create the scientific and technical products.

When analyzing financial activity, it is of great importance to consider the structure of funds received by an SPE for funding with resources, interaction degree with organizations, industry enterprises, as well as with third-party organizations. Main sources of the research funding in relation to, for example, a sectoral ministry include: R&D fund; funds centralized by the ministry; return fund; funds of the ministry enterprises; state budget; third party funds; contracts; organization financing for the research work.

Such an analysis should be carried out within the recent years dynamics in order to identify trends in the enterprise structure alteration indicating demand from the customers. Analysis of the financial resources structure by customers makes it possible to identify relationships with them and provides for consideration of the financial resources motion by contractors involved in creation of scientific and technical products. Analysis process ensures comparability of planned and reporting data. In practice, the costs are grouped by topics, calendar periods, cost items, sources of funding, branches, departments, etc.

Costs by items depending on their purpose and place could be divided into those directly related to scientific activities (wages, accruals for wages, travel expenses, materials, special equipment, enterprise structural divisions expenses, costs of third-party organizations); related to maintenance and management (depreciation deductions, deductions to the repair reserve, overhead costs).

Management decision-making techniques and methods. SPE specificity as a management object, variety in the organization operation, wide range of tasks solved in the scientific research management system require introduction of various logical techniques and methods of analytical work to prepare initial data for decision making.

Comparison is the most universal and widespread analysis method, where assessment of the object under study (SPE and its structural divisions) is carried out using the other similar objects.

Analytical grouping method consists in selection of characteristic groups among the studied SPE and its structural divisions according to certain groups of characteristics.

Detailing is the method of dividing the SPE operation factors and results by time and place making it possible to reveal positive and negative effects of individual factors on the results of scientific activity in general.

Average values reception in a generalized form reflects the SPE processes essence. Average values could be widely used to identify such indicators as average profitability of individual units, average duration of a single development, etc.

Share participation is used in cases, where interaction of factors with a productive sign (indicator) corresponds to the algebraic sum. To calculate the factors, the so-called share participation ratio is calculated, i.e., the ratio of the analyzed indicator to the sum of indicators interconnected with the analyzed one.

Simulating the process of creating innovations. It is used to quantify the state of ideas in the past to the present moment and forecast for the future [12–16]. Scientific and technical problems development is carried out during the full life cycle of the relevant ideas' implementation.

Overall life cycle of the ideas' implementation is an ordered set of stages. This work determines the specified set of stages as follows: first stage is fundamental research, second stage is applied studies, third stage is design, fourth stage is development, fifth stage is production of a prototype, and sixth is prototype testing and finishing to a production sample. Let us note that division of the overall life cycle (OLC) into stages is rather arbitrary. Often, three more stages are added to the listed six stages: mass production, operation and modernization (modification). Here, the ideas' implementation OLC is limited by the six listed stages.

When passing through the OLC stages, ideas interact with the external environment. Result of exposure to the external environment of the ideas lies in a certain increase in the completeness degree of the idea development. For each external environment and for each OLC stage, this completion increase is determined by the corresponding (production type) function.

Production function of any idea implementation OLC stage reflects the relationship of resources with an increase in the idea development completion degree obtained at this stage, and thus makes it possible to evaluate the effectiveness of technologies used at this stage of development [12–15]. It should be noted that in relation to the first four stages of the idea development process, it is mainly about the effectiveness of information technologies.

The essence of mathematical simulation problem in creating innovations is as follows. Living labor, funds and labor results of the previous stage constitute resources of each stage of the idea development. At the same time, information is the result of work at least during the first four stages.

It is known that the OLC duration in implementing the same ideas in different environments is different, which is the basis for introducing into the OLS characteristics composition ideas' implementation such a characteristic as the degree of ideas' obsolescence.

Ideas' implementation OLC mathematical model should reflect dynamics of the relationship between the parameters characterizing the cycle. If this condition is met, the mathematical model could be used to forecast the most important parameters of the innovation creation process.

Project of a mathematical model is proposed, which main purpose is the forecast of the most important parameters characterizing OLC of the ideas' implementation. The model is deterministic for a formal description using the differential equations apparatus [7].

The model includes the following features:

– t is time;

– h_{ph} is physical age of the idea;

– r is degree of the ideas' development completion;

– h_m is degree of obsolescence;

– C is residual cost of ideas' development;

– number of ideas not implemented by the t time ($N(t)$ function) and implemented by the t time ($R(t)$ function); therefore, $N(t) + R(t) = \text{const}$; functions $N(t)$ (functions $R(t)$), which would be built in the model, are called the model functions and are denoted by $N_m(t)$ (respectively, as $R_m(t)$); the functions $N(t)$ and $R(t)$ taken from the statistics are denoted as $N_{st}(t)$ and $R_{st}(t)$; density function of the number of unrealized ideas — n (h_{ph}, h_m, r, c, t) is function of the h_{ph}, h_m, r, c, t, for which the number of unrealized ideas in the W region of the $H_{ph} \times H_m \times R \times C$ phase space is expressed by the integral at the t time:

$$N(w, t) = \int_w n\,(h_{ph}, h_m, r, c, t)\, dw. \tag{1}$$

The H_{ph} = [0, 100], H_m = [0, 1], R = [0, 1] and C = [0, 1] parameters are the alteration intervals, respectively, of the ideas' physical age, degree of their obsolescence, development degree and residual cost of development.

This model describes the process of ideas' motion in space with the h_{ph}, h_m, r and t coordinates by differential equation of the representing points motion in the phase space:

$$\frac{\partial n}{\partial t} + \frac{\partial n}{\partial h_{ph}} + \frac{\partial (v_m n)}{\partial h_m} + \frac{\partial (v_m n)}{\partial r} = S. \tag{2}$$

In addition, time dynamics of emergence of those new ideas that enter the development process is set for $t > t_0$. Temporal dynamics of the new idea emergence is the t time-dependent function of new ideas distribution according to the h_m obsolescence degree and the r development completion degree. This function is denoted as n (0, h_m, r, t).

Additional conditions, i.e., the n (h_{ph}, h_m, r, t), n (0, h_m, r, t) and v_m, v_r, functions reflecting in the model the external environment effect on the process of developing ideas, make it possible to solve the boundary-value problems, thereby obtaining predictive estimates of characteristics of the ideas being developed as the n (0, h_m, r, t), v_m, v_r and S. Thus, it becomes necessary to solve the predictive problems to have the control coefficients (2), i.e., v_m and v_r, as functions of the h_{ph}, h_m, r, t variables and the control right side (2), i.e., the S = = S (h_{ph}, h_m, r, t).

The way to determine the v_m and v_r is solution to the so-called inverse problems for differential equation (2). Inverse problems for differential equations are understood as problems in determining coefficients or right-hand sides of equations from certain functionals of their solutions. When solving inverse problems, functions that make up additional conditions in the initial and boundary value problems considered earlier could also be unknown.

In many inverse problems, integral characteristics are the known functionals. In our case, such an integral characteristic is the function of the number of not completed ideas by the t time, i.e., the following function:

$$N_m(t) = \int\limits_{H_{ph} \times H_m \times R} n\,(h_{ph}, h_m, r, t)\,dw. \quad (3)$$

This $N_m\,(t)$ function is important in studying the process of developing, because it has statistical data, i.e., the $N_{st}\,(t)$.

It should be noted that inverse problems in this model are not just the v_m, v_r and S coefficients estimate, i.e., the equation identification (2) necessary for subsequent solution of the forecast problems. The fact is that the indicated identification of equation (2) is a way to solve an important problem, i.e., qualitative assessment of the external environment influence on the dynamics of the ideas' implementation OLC characteristics. As a result of solving the forecast problem for each specific external environment and for each moment of time $t > t_0$, the functions of the number of ideas (h_{ph}, h_m, r, t) density, distribution of ideas by physical age, by the degree of obsolescence and the degree of completion of the ideas' development are obtained.

Using statistical data on the number of ideas in pre-selected and sufficiently large set being incomplete by the t time, the following characteristics could be obtained giving an idea of dynamics in the idea development process [7].

1. Distribution of ideas entering the development process according to the h_m degree of obsolescence and the r degree of development completion, i.e., the $n\,(h_{ph}, h_m, r, t_0)$ function at $h_{ph} = 0$ (Fig. 2).

Distribution function for ideas entering the development process according to the degree of development completion, i.e., according to the r at $h_m = 0$, is shown in Fig. 3.

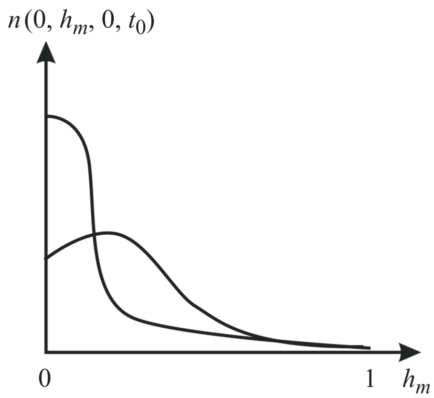

Fig. 2. Distribution of ideas entering the development process according to the h_m degree of obsolescence

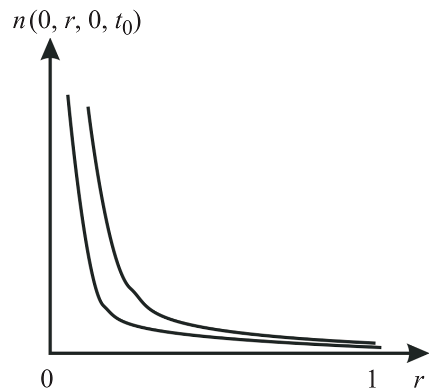

Fig. 3. Distribution of ideas entering the development process according to the r degree of development completion

The v_m and v_r parameters in equation (2) are functions of the h_{ph}, h_m, r, t variables and are called the rate alteration fields, respectively, of the obsolescence degree and of the degree of the ideas development. The v_m and v_r functions reflect result of certain environmental factors impact on the obsolescence process and on the ideas development promotion. They are defined by the following relations:

$$v_m = \frac{dh_m}{dt}; \tag{4}$$

$$v_r = \frac{dr}{dt}. \tag{5}$$

The v_m and v_r parameters are projections of the vector field of ideas motion rate in the $H_{ph} \times H_m \times R$ space on the corresponding coordinate axes:

$$\overline{v} = v_{ph}\,\overline{i} + v_m\,\overline{j} + v_r\,\overline{k}. \tag{6}$$

Relations (4) and (5) not only serve to determine the v_m and v_r functions, but in case the v_m and v_r functions are independent from the n (h_{ph}, h_m, r, t) function, they make it possible to calculate the trajectories of ideas motion in the $H_{ph} \times H_m \times R$ phase space.

The S right side in equation (2) also reflects the fact of the external environment interaction with the h_m and r characteristics of ideas. In the most trivial case, $S = 0$. This case will be considered in detail below. In the case, where $S \neq 0$ S (h_{ph}, h_m, r, t) is able to set, for example, the number of ideas with the h_{ph}, h_m, r, t, parameters withdrawn from development for various reasons at the t time. Thus, the environment parameters affecting the ideas motion in the $H_{ph} \times H_m \times R$ phase space could be conditionally divided into two groups. Results of interaction between the ideas characteristics and the environment parameters of the first group are presented in the v_m and v_r functions. Influence of the second group of environment parameters is reflected in the S interaction integral.

Equation (2) is a linear partial differential equation of the first order with respect to the n (h_{ph}, h_m, r, t) function; its main purpose is to solve the direct problem. And solution of the direct problem for equation (1) is the solution of equation (2) relative to the n (h_{ph}, h_m, r, t) function for the v_m and v_r given (known) functions (coefficients), i.e., for known or estimated in any way effects of the environment on the h_m and r ideas characteristics. Of course, the right side of equation (2) should also be determined. Thus, in our case, the direct task to solve equation (2) relative to the h_{ph}, ideas distribution function by physical age, the h_m obsolescence degree, the r completion degree and the residual cost of developing ideas is the task of forecasting the specified distribution function, i.e., the $n\,(h_{ph},\ h_m,\ r,\ t)$ function. The function in this model characterizes dynamics of the development process for a sufficiently high number of ideas.

To solve the forecast problems related to differential equation (2), additional conditions are required. From the point of differences between these additional conditions, three main types of forecasting tasks could be distinguished.

Initial problems of the general type. In these problems, the $n\ (h_{ph},\ h_m,\ r,\ t)$ function is specified at the t_0 initial time as an additional condition.

The meaning of this task lies in the fact that in the constantly ongoing process of developing ideas, the state of this process is being registered at the t_0 time. Solution to equation (2) for the $t > t_0$ moments of time provides dynamics of alterations in the structure of the initially given state of the ideas' development.

Cohort problems are a particular (but rather important) case of the general initial problems. Here, an additional condition is the cut of the $n\ (h_{ph},\ h_m,\ r,\ t_0)$ function at $h_{ph} = 0$, i.e., the function is $n\ (h_{ph},\ h_m,\ r,\ t_0)\big|_{h_{ph}\,=\,0} = n\ (0,\ h_m,\ r,\ t_0)$.

Cohort problems consider dynamics of the structure of ideas being developed that appeared over a certain period of time by the t_0 time, i.e., the fate of the development of a certain cohort of ideas is being traced. In this case, equation (2) is somewhat simplified, since $h_{ph} \equiv t$ in the cohort problems. Equation (2) looks as follows:

$$\frac{\partial n}{\partial t} + \frac{\partial (v_m\, n)}{\partial h_m} + \frac{\partial (v_r\, n)}{\partial r} = S. \tag{7}$$

The so-called boundary value problems are the most general and adequate form of direct problems for equation (2). In boundary value problems, as well as in initial problems of a general form, the state of the ideas' development is set at the t_0 certain point in time, i.e., the $n\ (h_{ph},\ h_m,\ r,\ t_0)$ function.

2. Trajectories of the ideas motion in space with the h_{ph}, h_m and r coordinates of families of these trajectories is convenient to depict by projecting the space of motion on the $H_{ph} \times H_m$ and $H_{ph} \times R$ plane; the family of curves describing alteration in the obsolescence degree of the ideas under development is designated as $h_m\,(h_{ph},\ h_m^*)$ and shown in Fig. 4.

Not all trajectories in Fig. 4 reach the $h_m = 1$ obsolescence degree, since development of ideas in this model is considered until creation of a production prototype, and production prototypes could appear in reality with different obsolescence degrees. The family of trajectories representing alteration in the completion degree of the ideas' development is denoted as $r\ (h_{ph},\ r^{*})$ and is shown in Fig. 5.

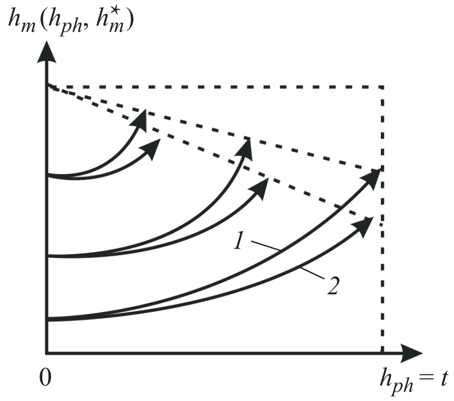

Fig. 4. Family of curves describing obsolescence degree of the curves under development (curves *1*, *2* are 1st and 2nd environments)

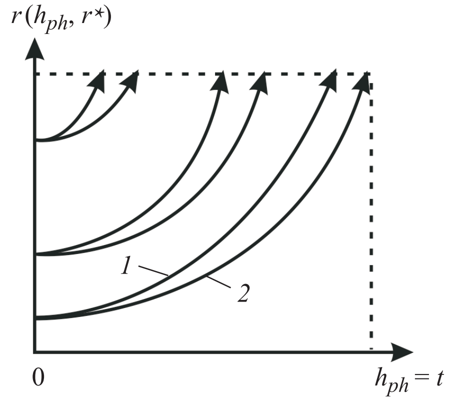

Fig. 5. Family of trajectories representing alteration in the degree of completion of the idea' development (curves *1*, *2* are 1st and 2nd environments)

3. Model curve of the number of ideas not completed by the t moment of time, i.e., the $N_m\ (t)$ function at $t = 0$ $N_m^1(0) = N_m^2(0)$ (motion of the same set is considered in two different environments, Fig. 6).

The use of intelligent systems based on knowledge, as well as methods and means of artificial intelligence, makes it possible to pass to a qualitatively new level of the SPE scientific research management.

SPE document workflow intellectualization. The problem of document workflow intellectualization is related to the fact that modern intelligent systems should solve the entire complex of tasks connected to managing the flow of incoming documents: their automatic classification and indexing, prompt and adequate distribution among enterprise employees, transfer to the electronic archive and subsequent search for documents in it by content [3, 9, 16].

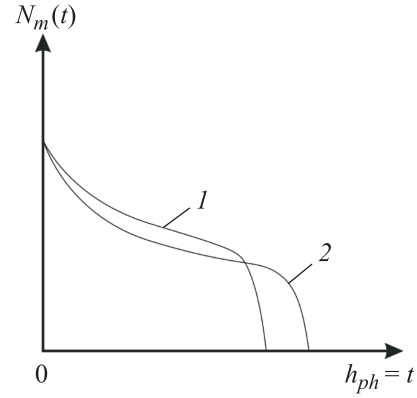

Fig. 6. Model trajectories of ideas not completed by the *t* time (curves *1*, *2* are 1st and 2nd environments)

An important aspect that should be taken into consideration when developing the information systems support intelligent document workflow is the requirement for their customizability during operation [9]. Failure to comply with this requirement could lead to the fact that the system would stop performing its functions over time due to changes in the SPE structure, its personnel, circle of partners or range of operations performed, which inevitably lead to alteration in the system of concepts, subject of documents and corresponding conditions for their classification, indexing and addressing.

These problems could not be solved either by traditional approaches to document workflow automation, or by generally accepted statistical or linguistic methods of full-text search in the document database [5]. Here, intelligent solutions are required orienting the process of automatic document processing towards understanding the content of a text.

The proposed approach is based on using the knowledge about the subject area and on the linguistic analysis of genre structure and content of business letters received by an enterprise using the information system.

Within the framework of this approach, a technique for automatic analysis of the text of documents and its meaningful indexing is proposed, which served as the basis for the development of technology for intellectualizing the document circulation procedures. Technology is understood as a set of methods and tools used to solve classes of problems in a certain problem area.

To implement the discussed approach, a scheme of the document workflow system is proposed, it is presented in Fig. 7.

Document workflow management system includes the following contours in working with documents: document input and initial processing (document input subsystem); automatic processing, document indexing and distribution (the document indexing and addressing component); document operational search and issuance in accordance with the content (search subsystem).

The entire knowledge about the subject area and the document language is entered by the expert user into the knowledge base through the appropriate automated workstations (AWS). The same AWS makes it possible to customize the knowledge base, if the environment and operating conditions of the system are changing.

The proposed technology would refer to a really developed system focused on the subject area of the NPO “Lakokraspokrytie”, which includes a research institute, a machine-building plant, design, development and production departments, commercial and marketing services controlled and managed according to the matrix principle. At the first stage, it was necessary to accept a number of proposals in the internal organization of this enterprise operation. A number

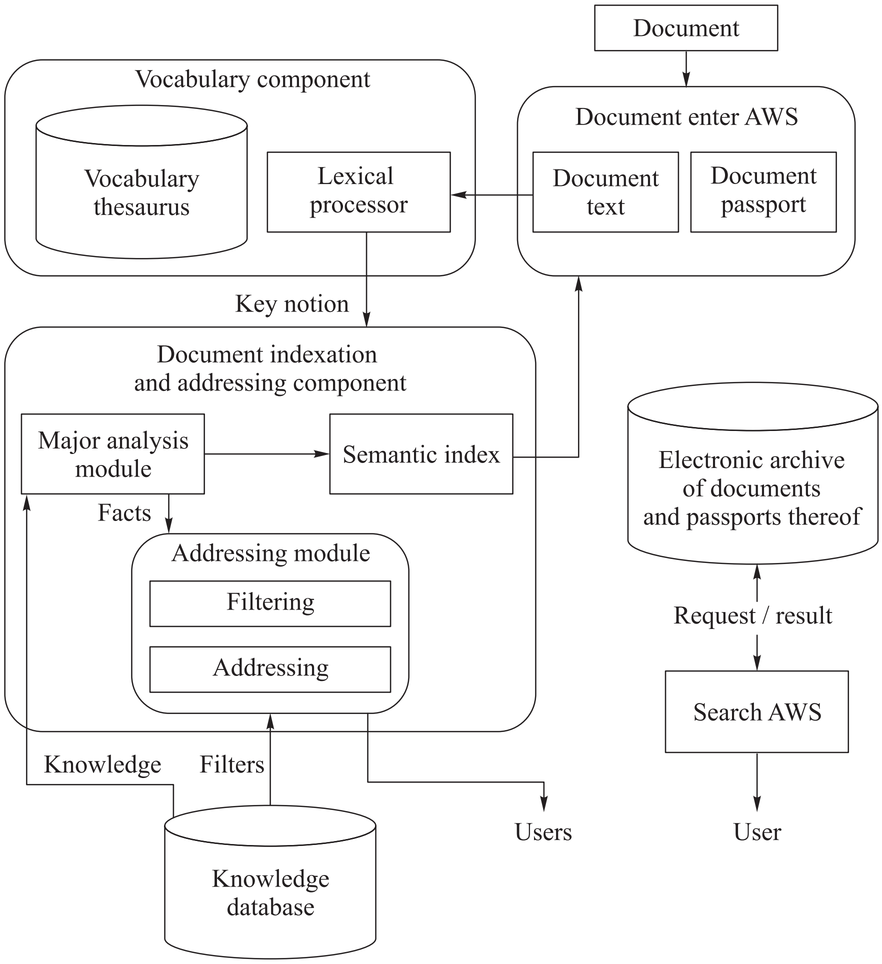

Fig. 7. Document workflow management system

of regulations were accepted and adopted: on the procedure for contracts accepting, on the scientific and technical council, on the general director, on bonuses, on young scientists.

Technology in using the information system. The developed information system tracks scientific developments from the planning stage to its implementation making it possible to receive the output information within the calendar time scale. At the same time, comprehensive analysis for each version of a draft plan is performed at the organization level aimed at assessing the financial and economic indicators and the scope of work.

When concluding a contract on the request, the planning and coordination department identifies the “contract concluded” mark, enters the contract number instead of the request serial number; besides, missing data and correcting outdated data on deadlines, planned costing of work and others are also entered.

The process of performing the work stages requires entering the actual costs for their implementation into the database, which the system presents on a quarterly basis as a cumulative sum. Economists on a quarterly basis also submit a financial report reflecting financial results for the reporting period (quarter, half year, 9 months, year). At all levels of management, forms of analysis of the research activities and forms of control over expenditure of funds on operations and other areas are used to fulfill functional duties of the decision makers.

After the operation stages are fulfilled, acceptance/delivery certificates are compiled with the customer, and they are taken into account in the information system input data and could be controlled. Besides, payment for works after paying the invoices by a customer is staying under control.

At the end of the planned year, the organization scientific research is analyzed in order to summarize and develop recommendations for a more effective funds redistribution in the next year. The past year is being closed and all its operations are transferred to the archive available to users.

Automated information system (AIS) functions distribution by management levels is provided in the Table.

AIS functions compliance with management levels

Management level	Functions used
Directors of scientific research enterprises	Monitoring implementation of scientific research, including all co-contractors for this work throughout the entire work. Access to the archive of the institute completed works
Unit managers, project managers	Ensuring preparation of initial data on the draft plan, analysis of the unit operation, control over the unit operation performance, financial reporting on the work. Access to the archive of the institute completed works
Institute top management, planning and coordination department	Scientific research and financial analysis of the enterprise activity to make management decisions in the enterprise operation improvement
Project maintenance group	Input data periodical verification, data base administration, data archivation, new user training

Reasonable AIS software architecture having distributed nature supports interaction between its constituent elements in the “client-server” mode to ensure prompt access to information, improve reliability of data storage and processing, and support a single centralized data bank of ongoing scientific research.

The three-layer implementation of this architecture improves performance and facilitates system maintenance.

Conclusion. Management decision-making support requires the use of special techniques and methods. Most effective of these include the following methods: comparison, analytical grouping; detailing; acceptance of average values and share participation; simulating process in creating innovations.

The life cycle of ideas concept is introduced and a mathematical model of the innovations creating process is proposed making it possible to quantify the state of a set of ideas in a particular knowledge area in the past to a given point in time and forecast its state for the future.

Organization of operations using elements of the intellectual system for managing scientific research made it possible from 2005 to 2020 to increase the NPO "Lakokraspokrytie" income by 20 times, despite the crises of 2008 and 2014.

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REFERENCES

[1] Meshalkin V.P. Logistika i elektronnaya ekonomika v usloviyakh perekhoda k ustoychivomu razvitiyu [Logistics and e-economy in transition to sustainable development]. Moscow, MUCT Publ., 2004.

[2] Meshalkin V.P., Kakatunova T.V. Information systems of innovation management in regional industrial complexes. *Zhurnal pravovykh i ekonomicheskikh issledovaniy* [Journal of Legal and Economic Studies], 2011, no. 4, pp. 191–193 (in Russ.).

[3] Garipova G.R., Shinkevich A.I. Upravlencheskie innovatsii. Sostoyanie i perspektivy razvitiya [Management innovations. Current state and development prospects]. Kazan, KNITU Publ., 2015.

[4] Orlov A.I. Organizational-economic modelling in the control problems of economic units. *Innovatsii v menedzhmente* [Innovations in Management], 2014, no. 1, pp. 22–31 (in Russ.).

[5] Sheremet A.D., Sayfulin R.S. Finansy predpriyatiy [Enterprise finance]. Moscow, Infra-M Publ., 1998.

[6] Amelina K.E., Korobets B.N. Algorithmization of organization management as a tool to improve its performance. *Nauka i biznes: puti razvitiya* [Science and Business: Development Ways], 2015, no. 10, pp. 24–26 (in Russ.).

[7] Dorokhov I.N., Men'shikov V.V. Sistemnyy analiz protsessov khimicheskoy tekhnologii [System analysis of chemical technology processes]. Moscow, Nauka Publ., 2005.

[8] Meshalkin V.P., Stoyanova O.V. Procedure for constructing model of innovative projects in the field of nanoindustry. *Theor. Found. Chem. Eng.*, 2014, vol. 48, no. 1, pp. 82–89 (in Russ.). DOI: https://doi.org/10.1134/S0040579514010059

[9] Bobyleva M.P. Upravlencheskiy dokumentooborot: ot bumazhnogo k elektronnomu [Management of document flow: from paper to electronic]. Moscow, Termika.ru Publ., 2019.

[10] Kolobov A.A., Omelchenko I.N., Orlov A.I. Menedzhment vysokikh tekhnologiy [High technology management]. Moscow, Ekzamen Publ., 2008.

[11] Meshalkin V.P., Puchkov A.Yu., Dli M.I., et al. Generalized model for engineering and controlling a complex multistage chemical energotechnological system for processing apatite-nepheline ore wastes. *Theor. Found. Chem. Eng.*, 2019, vol. 53, no. 4, pp. 463–471 (in Russ.). DOI: https://doi.org/10.1134/S0040579519040237

[12] Hausser R. Foundations of computational linguistics. Berlin, Springer Heidelberg, 1999.

[13] Bogomolov B.B., Boldyrev V.S., Zubarev A.M., et al. Intelligent logical information algorithm for choosing energy- and resource-efficient chemical technologies. *Theor. Found. Chem. Eng.*, 2019, vol. 53, no. 5, pp. 709–718.
DOI: https://doi.org/10.1134/S0040579519050270

[14] Brom A.E. Razrabotka kontseptsii i metodologicheskikh osnov sozdaniya organizatsionnoy sistemy logisticheskoy podderzhki zhiznennogo tsikla naukoemkoy produktsii. Diss. d-ra tekh. nauk [Development of concept and methodological foundations or the development of organizational system for logical support of high technology products life cycle. Dr. Sc. (Eng.). Diss.]. Moscow, Bauman MSTU, 2009 (in Russ.).

[15] Boldyrev V.S., Averina Yu.M., Men'shikov V.V., et al. Technological and organizational engineering of paint processing. *Theor. Found. Chem. Eng.*, 2020, vol. 54, no. 3, pp. 420–424 (in Russ.). DOI: https://doi.org/10.1134/S004057952003001X

[16] Mishchenko A.V., Pilyugina A.V. Dynamic models of research and manufacturing system management. *Herald of the Bauman Moscow State Technical University, Series Mechanical Engineering*, 2019, no. 2 (125), pp. 56–75 (in Russ.).
DOI: https://doi.org/10.18698/0236-3933-2019-2-56-75

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