OPTIMIZATION OF ADMINISTRATIVE DECISIONS IN THE SYSTEM OF ECONOMIC AND ENVIRONMENTAL RESTRUCTURING OF AN ENTERPRISE

Lyudmila N. Rodionova[1]
Igor N. Dyshlovoi[2]
Olga V. Prokhorova[3]

1. Federal State Budgetary Educational Institution of Higher Education "Ufa State Aviation Technical University"
2. V.I. Vernadsky Crimean Federal University
3. V.I. Vernadsky Crimean Federal University

Abstract: The aim of the paper is to study and develop the processes of economic and environmental support for the restructuring of enterprises in Russia and abroad. To achieve this goal, the paper substantiates the relevance of environmental assessment of the restructuring system, reviews the theoretical bases and practices of economic and environmental aspects, presents the methodology for the formation of ecological and economic system in enterprises during the restructuring. It is known that environmental measures are financed on a residual basis. The problem of optimization of financial resources aimed at the update of business processes and environmental measures is relevant both for the operation of enterprises and its restructuring. The paper substantiates the need for planned and preventive economic and environmental support of enterprises. Due to this, the authors developed and proposed the cost allocation for the measures to reduce environmental risks of the enterprise using the mathematical programming, especially, the vector optimization (Pareto set). The proposed methodological recommendations based on optimizing the cost of environmental measures in the ongoing restructuring to ensure the maximum total reliability allows a more rational funds distribution in the system of administrative decisions.

Keywords: economic and environmental system, optimization of financial resources, vector optimization, restructuring of enterprises.

1. INTRODUCTION

The current environmental situation and trends are largely determined by industrial production and economic activity. Despite some successes and achievements, the overall state continues to deteriorate, leading to the further expansion of the environmental crisis in the world. The main reason for this situation is inefficient environmental control and management mechanisms used in industrial production, which are mainly based on strict administrative methods and enforcement. A civilized market needs an economic interest in reducing the environmental damage and compensating the losses. Due to the changed economic and legal relations between the owner and the state, the industrial companies are also interested in reducing environmental risks, since the damage compensation to the natural environment and society falls on the enterprises themselves.

The Russian Federation today is characterized by a lack of understanding and underestimation of the ongoing changes in solving environmental problems, up to com-

plete disregard of such changes. Another opinion is the extreme simplification and limiting to the formal implementation of a number of common requirements. Such a position leads to inevitably missed economic opportunities and direct losses, both for individual industrial companies and for the country. The increasing number of explicit and implicit restrictions and corresponding losses for Russian producers in international commodity and financial markets may serve as an example.

The aim of the paper is to study and develop methodological principles and practical recommendations for economic and environmental support of enterprise restructuring. To achieve this goal, the following tasks were solved:

- substantiation of the need for environmental assessment of the enterprise restructuring system;

- analysis of the terminology of the enterprise restructuring theory;

- analysis of methodological support of environmental aspects of enterprises;

- development of methodology to optimize the cost of environmental protection measures in the system of enterprise restructuring.

2. MATERIALS AND METHODS

Analysis of practical aspects of the problem. The global trend of stricter legislation in environmental protection suggests that only economic and environmental support for the restructuring of enterprises is the only way to survive in the modern environment. The restructuring of the enterprise has high expectations in improving the efficiency of production and ensuring the competitiveness of the manufactured products, which should economically support financial stabilization.

The authors believe that in Russia, the paradoxical situation of "free" use of natural resources in the economy or their minimum price, which has been developing until recently, was one of the reasons for the irrational use of natural resources, the huge wastefulness of the economy. There was an illusion of inexhaustibility, "gratuitous" nature of resources. Industrial and agricultural enterprises have mismanaged and are now using the means of production of natural origin, with little responsibility for any damage (or making minimal payments for pollution), which allows them to overestimate their production results.

The economists are aware of the "ecological inferiority" of the modern economy. For example, the study of a group of experts conducted under the leadership Of R. Constanta (University of Maryland) singled out 17 categories of functions and services of nature, which included the regulation of climate, gas composition of the atmosphere, water resources, soil formation, waste processing, genetic resources, etc. The calculations of these scientists produced a total estimate of these functions at an average of 35 trillion USD, which is twice the GNP created by mankind (18 trillion USD per year) [9].

According to Bobylev S. N. and Stetsenko A. V. [9], adequate consideration of the economic value of nature requires the determination of at least a cost estimate of three natural functions: provision of natural resources; assimilation of waste and pollution; provision of people with natural services such as recreation, aesthetic pleasure, etc. These three functions can also be presented as components of one common function of the natural environment – the life support. If the first function of the market economy is often undervalued, the economic estimates of the second and third natural functions are either absent or minimal. Namely, these costs of assimilation potential and natural ser-

vices are crucial for determining the economic value of many natural functions, for example, the preservation of biodiversity of protected areas.

The authors believe that the consideration of the economic value of nature is essential for improving environmental protection and the use of natural resources. This is very important, especially for the right economic decision-making. It is necessary to determine the economic feasibility, compare costs and benefits in order to make such decision. The missing or underestimated value of natural goods results in a deliberate reduction in the benefits of their preservation. The problem is that nature as a commodity has no price, so as a result, when comparing different development options; the option of preserving nature loses compared with traditional economic solutions.

In Russia, this situation is clearly manifested in making decisions in favor of the development of the extractive industry, forest and agricultural sectors. The insufficiency of modern environmental financing in Russia can be shown in its absolute terms in comparison with the USA. The annual costs for atmospheric air protection in the USA are approx. USD 35-40 billion average for the last 10 years. Similar costs in Russia amounted to less than $2 billion. That is, in absolute terms, about 20 times lower than in the United States. The same ratio occurs in other areas of environmental protection. Of course, the given level of costs in the US is impracticable for Russia in modern conditions [15].

In developed countries, the approach to environmental problems by the government is quite strict: the pollution standards of harmful substances in exhaust gases are toughening up. In order not to lose its market share in the current conditions, Honda Motors software-implemented the priority of the purity of the exhaust with the help of microprocessor control of the ignition system, instead of "squeezing" the extra HPs from the engines. At the intermediate stage, exhaust toxicity decreased by 70%, and the engine power reduced by only 1.5% [13].

The market methods to regulate the purity of environment carried out in the United States since the 70s of the last century are much interesting. One of them, the so-called "bubble principle" is based on combining the state and regional interests with the interests of individual entrepreneurs. The state establishes a certain limit on environmental pollution for each region, which should be maintained in the joint operation of regional enterprises. Those enterprises that manage to reduce emissions (that is, their discharges are below the permissible level) could use their "surplus reduction" for sale to other regional enterprises that have their emissions above the standard. There are five "environmental banks" in the country, the deposits to which are these "surpluses" [15].

Japan has different, no less rigid system for new enterprises: new construction and reconstruction projects are required by law to have the volume of pollutant emissions per unit of production 7 times lower than its level at existing enterprises. The advantages of this system are that it stimulates the entrepreneur to the most saving solutions to the task of environmental protection, i.e. creates conditions for the introduction of more cost-effective and clean technologies.

The overall economic growth and changes in the environment are closely related. With the development of social production, the influence of man on nature and the use of its resources is increasing. In this regard, the consideration of social development without due regard to environmental factors and the laws governing the relationship of society and nature may lead to undesirable economic and social consequences. The further development of production powers is connected with the involvement of significant amounts of natural resources in the economic turnover and an increase in the environ-

mental load. The state of the environment can significantly influence the development of production forces, accelerating or slowing down its dynamics.

Social development has numerous contradictions between the increasing needs of people and the limited capacity of the biosphere, natural resources to meet them, as well as the relationship between the state of the environment and the pace of economic growth. Maintaining the high pace of economic growth without implementing corresponding environmental policies leads to environmental degradation. The economic losses caused by pollution and depletion of natural resources mean the actual decline in the rate and level of national income achieved.

Recently, the media has been talking much about environmental problems, the critical level of environmental pollution, and the environmental crisis. Many people think that the solution is the introduction of resource-saving technologies, reducing emissions, the use of secondary raw materials, and direct environmental measures (construction of various treatment facilities, filters, creation of protected areas, etc.).

Now the most cost and environmentally effective way to solve environmental problems are alternative solutions. One of them is the restructuring of the economy, that is, the redistribution of financial, labor and material resources in favor of resource-saving, technologically advanced industries and activities. According to numerous estimates, the change in the structure of the economy will release 20-30% of the inefficiently used natural resources with an increase in the final results. These released resources pass to the state, which finds them an effective owner.

Unfortunately, the level of competitiveness of Russian enterprises does not correspond to the international one. The country has highly educated staff, natural resources, huge market potential, as well as the opportunity to purchase the latest equipment. Moreover, despite the widespread opinion, business leaders have real opportunities to attract the necessary capital. The restructuring of enterprises is meant to solve these problems.

Analysis of the theoretical bases of the subject

The implementation of restructuring programs can significantly improve the competitiveness of companies, lead to overcoming negative situations in economic development, and solving problems of environmental protection. he Russian practice of economic activity has widely used the concepts like "reform", "restructuring" and "reorganization" of enterprises, while many of the researchers are trying to interpret these terms in their own way; often one concept is replaced with the other. I observed it even in officially published documents. The authors believe that the concept of "reform" does not refer to the enterprise, but to the industry as a whole or to the economic system.

The following sources [20, 21] indicate that restructuring is the main means of reforming the enterprise. This process involves improving only the structure of the enterprise, not the management functions, as the authors point out. Improvement of enterprise administrative functions refers to the concept of "reorganization". Other authors - Trenev V. N., Irikov V. A., S. V. Allemanov [26] - put together both "reform" and "restructuring". In their opinion, the reform refers to the strategy and reorganization of the enterprise, and restructuring – mainly to changes in the structure of the enterprise and its products. However, one can say for sure that restructuring is not the only means of reforming enterprises, and the above gradation of actions corresponding to these concepts is not exact.

Restructuring according to [19] is "...structural reorganization in order to ensure the efficient distribution and use of all resources of the enterprise, which consists in the

creation of a complex of responsibility centers on the basis of division, connection, liquidation (transfer) of existing and organization of new structural units, accession to the enterprise of other enterprises, acquisition of a certain share in the authorized capital or shares of third parties". This definition specifies the concept, indicating that restructuring refers to changes in the structure and the enterprise and its products. The author does not differ the concept of restructuring and reorganization. Division, consolidation, and liquidation of existing units and joining other enterprises refers to the concept of reorganization, not restructuring.

According to [20], restructuring is a complex optimization of the enterprise functioning system in accordance with the requirements of the external environment and the existing strategy of its development. It contributes to the fundamental improvement of management, increase of efficiency and competitiveness of production and products on the basis of modern approaches to management, including the methodology of quality management, re-engineering of business processes, information technologies and systems, etc. The authors can say that this definition balance all aspects of the enterprise and implies a systematic nature of optimization.

From the point of view of the system approach, all the authors make a system error while missing a link of the studied category with the environment. The ties within the system covered by all authors, but interaction with the external environment, social and environmental aspects are not studied. However, these problems significantly affect the activities of the enterprise. There are numerous examples to this fact: Environmental pollution caused by the company leads to an increase in the morbidity of the working population (from the same company), and, consequently, reduces its financial performance. Today, when the environmental situation becomes more and more threatening, addressing the issues of restructuring in order to change the management system for finance, the company and the organizational structure, one cannot but take into account social and environmental problems.

The authors think that restructuring is the process of complex optimization of the financial and economic activity of the enterprise, regarding the influence of the external environment and existing development strategy. Now, in the setting of an acute environmental crisis, one can think of introducing environmental measures in restructuring of enterprises, not only to stabilize the environmental situation, but also to improve the quality of the environment. To enter the international market, the successfully functioning enterprises need such restructuring, while the unprofitable ones need incentive measures from the state to carry out restructuring simultaneously with measures to overcome the crisis.

The moment when environmental protection will be of interest to business executives no less than the main production will be the moment of the transition to economic and environmental thinking in production activities, and towards the interest in environmental management. It should be noted that the restructuring scheme of each enterprise is individual, therefore it requires due regard to its industrial and production and technical characteristics, relationships between departments, and the existing property relations.

In author's opinion, nowadays the several common scenarios that have emerged in the course of the ongoing organizational reforms of Russian enterprises can be distinguished. They are: conclusion of lease agreements with structural units; creation of subsidiaries; transfer, sale and commercial use of social facilities; allocation and sale of auxiliary, not corresponding to the strategic concept of the enterprise units and types of

business, as well as the formation of large production complexes of technologically related enterprises.

Many Russian economists (B. Mil'ner, Kh. Mingazov, Yu. Vinslav etc.) noted the dangerous phenomena in the organizational restructuring of large enterprises and associations. There are many examples of artificial fragmentation and disaggregation leading to disruption of the technological chain and reduction of strategic opportunities. One of the negative examples is the creation of 400 independent airlines on the basis of a single Russian airline "Aeroflot". Only 20 of these created were viable [21]. According to many leading economists, it is not the destruction, but the transformation of existing forms of integration into market structures can give a real chance to holdings, consortia, and business associations – the modern corporations of associative type.

Practice shows that a prerequisite for achieving financial well-being of the enterprise is a rational management scheme. The most important instrument in this scheme is modern information technology, and, in particular, an integrated enterprise management information system. The system can help a company, which is widely distributed geographically, to achieve "transparency" and manageability of financial and commodity flows on a day-to-day basis and to become one of the most powerful levers in the implementation of strategic plans.

The authors believe that at a time when the environmental situation is becoming more threatening, while addressing the restructuring, one cannot but consider the environmental problems. Currently, the enterprises need the establishment of interrelations between results of economic activity and indicators of ecological compatibility of products, as well as its production technology.

The inevitable environmental restrictions on business activities and the regulatory role of the state in environmental management and protection is increasingly considered by leading economists and environmentalists [13, 16, 18, 24] as the only way out of the crisis. One of the main problems of modern production systems, despite the measures taken, is numerous accidents. At the same time, the scale of individual accidents is growing, and their consequences are becoming more severe. At the present stage of social scientific and technical development, it is impossible to ensure absolute safety of complex technical systems and technologies. In systems that have stored energy of chemically and biologically active components, zero risk is impossible, the accidents are always possible. Recognition of this fact radically changes approaches to environmental safety of industrial facilities, technologies and systems. The real reduction of the industrial production hazards lies in the transition from the concept of "absolute safety" to the concept of acceptable risk and industrial safety management of the production facilities. All this can be achieved at the stage of planned preventive production restructuring [1,2].

Economic reforms in Russia that radically changed the management system, as well as the nature of the business environment, determined a new view of the enterprise's capabilities in the environmental sphere. This is reflected in the works by I. Afanasenko, V. Bil'chak, A. Bobrov, S. Bobylev, V. Voznyak, Ya. Vishnyakov, A. Golub, V. Ivchenko, N. Kiseleva, E. Korotkov, N. Pakhomova, I. Potravny, N. Reymers, G. Serov, and N. Tikhomirov. The scientific substantiation of the concept of economic and environmental development of the Russian Federation and its subjects is studied in the fundamental scientific works by L. Abalkin, A. Buzgalin, E. Girusov, V. Golubev, V. Danilov-Danil'yan, I. Krasovskaya, K. Losev, L. Nesterova, I. Potravny, B. Porfir'ev, A. Suetin, T. Khachaturov, N. Chepurnykh, and others.

The successful resolution of modern economic and environmental problems and the search for ways out of the extreme natural and economic crisis are largely due to the devel-

opment of a wide range of economic and environmental problems. Their analysis and resolution are studied in the works of the following foreign scientists: G. Blomtusta, B. Kommoner, D. Medouz, M. Mesarovich, E. Pestel', A. Pigu, D. Pirs, B. Uord, S. Uortner, J. Forrester, et al.

The current level of development of environmentally sustainable entrepreneurship is studied in the works by R. Uelford, G. Vinter, A. Gauldson, K. Gofman, T. Dillik, D., Ottmann, K. Pitti, M. Porter, K. Rikhter, P. Roberts, V. Khopfenbeck, S. Shmidkheyni, etc. The air and water pollution can harm the population, the destruction of recreational ecosystems leads to adverse social consequences, the pursuit of cheap raw materials can cause its deficit. The consequences are the damage to the enterprise, which could be much less if a set of environmental measures have been taken timely.

Methodology for the formation of economic and environmental system in the enterprise

The authors believe that the resolution of the studied problems should be carried out through the creation and operation of ecological and economic systems, which are a set of resources (and methodological techniques for their optimization), technical devices and elements of the natural environment. On the one hand, they provide high production targets, and on the other, they maintain favorable environmental conditions in the zone of their influence, the maximum possible preservation and reproduction of natural resources [6, 8]. The production impact on natural systems is manifested in the extraction of natural resources, the disposal of industrial waste (pollution), etc.

In turn, the environment can also affect the enterprise. This impact leads to the destruction of the controlled subsystem, and consequently, the entire ecological and economic system. To avoid this, the compensatory measures from the controlled subsystem in relation to the control subsystem via negative feedback channels are required. The fact is that natural systems do not have enough information to compensate their impact on production. Therefore, the corresponding functions should be implemented in an ergonomic link of the system.

This means that a special control unit should exist in the ecological and economic system. It is to receive the information from natural systems about the changes in them, to assess the possible negative consequences, and to send the appropriate command to the management system (here – the producer). The control unit may be the authorities or specially authorized services (e.g. environmental protection services). They obtain information on the state of natural systems through control and monitoring and prescribe to the enterprise, for example, the reduction of emissions or discharges, engage economic levers of management, in particular, adjust pollution charges, etc. As for specific measures and ways of implementation of such requirements, they are chosen by the enterprise itself, solving the corresponding ecological and economic problem [1, 2, 15, 16]. This may include new treatment facilities, changes in technology, replacement of raw materials and fuel, and in some cases, the suspension of obsolete hazardous industries. This kind of control units is found during the production restructuring; they should have the "memory" to prevent possible environmental disturbances, otherwise – the reserves that may be excessive in the operation of the enterprise in stationary conditions and scarce in crisis situations. Determination of necessary and sufficient reserves of the enterprise functioning is an important task of economic and environmental management systems [18, 19, 20].

Now let us consider the main "environmental" points of this method. They are: analysis of the initial state of the system of economic and environmental management in the enterprise; formulation of the basic principles and directions of functioning of the

system of economic and environmental management; the main functions of the environmental safety service, development and compliance with environmental policy, environmental programs and basic requirements for the environmental management system; creation of the environmental insurance system; environmental audit and environmental reporting.

Analysis of the initial state of the system is carried out with the help of environmental audit. The most important function of the system is to analyze the current state of environmental quality management, which can be assessed by comparing with the initial state of environmental management and rational use of existing resources. The analysis covers the full range of operating conditions, including possible emergencies. The process and results of analysis should be documented, and the opportunities for developing an environmental management system should be confirmed.

The first step in the analysis of environmental quality management is development of a list of studied areas, which can be obtained from the analysis of the company's documentation, from direct measurements of environmental parameters, and from the analysis of the actions of third parties or their own departments. The practices of the latter may be adapted to improve environmental performance, materials of interviews and control surveys of the staff. The analysis of the state of environmental quality management can take the information from authorities of various levels, industrial associations, banks, funds, etc., consumer societies and other public associations, and business partners.

The authors believe that the analysis of the general environmental situation should pay special attention to the direction of funds for the implementation of measures for preventing emergency situations. Important information is obtained from the analysis of current payments of the enterprise. This case considers the total amount of payments, the distribution of payments (fees for emissions/discharges within the temporary coordination of emissions/discharges, excess payments/fines, sanctions), and the analysis of the distribution of payments by type of waste. The audit of environmental management systems, besides the usual verification of compliance with the criteria of the system (regulatory requirements), determines:

- the methodology of implementation and functioning of the system;

- the field of possible improvement of system characteristics;

- the ability of the company's management to analyze the results and efficiency of the system;

- the compliance of the environmental management system with the requirements of contracts with suppliers and consumers.

The final result of environmental audit is the conclusions about the management system of environmental protection and product quality management system. The authors think that the main principles of creating a system of economic and environmental management of the enterprise are:

- establishing the order that make environmental quality management one of the economic priorities of the enterprise;

- creating and financial stimulating the environmental infrastructure of the enterprise;

- establishing and maintaining links with internal and external stakeholders in efficient environmental policy;

- entering into agreement between management and employees on environmental issues with a clear understanding of mutual economic and other responsibilities;

- establishing the requirements of regulatory legal acts to the environmental aspects of the enterprise and clarification of compliance with these requirements of its impact indicators on the environment with the relevant economic sanctions for their non-compliance;

- initial assessment of the parameters of production and other processes necessary to achieve the required level of environmental performance of the enterprise;

- integrating the planning and environmental aspects into the life cycle of products or services;

- calculating, justifying and allocating the material, financial and human resources sufficient for the selected level of environmental sustainability;

- measuring economic and environmental management processes through inspections and identification of the possibility of improving the system of economic and environmental management of the enterprise (its audit);

- implementing and developing the subsystems of environmental marketing, engineering, environmental education, etc.

The main directions of the system functioning should be:

- consideration of economic feasibility in the development of environmental strategy;

- further improvement of environmental safety of industry facilities through the creation and implementation of environmentally friendly technologies and technical means;

- creation of a sectoral system of industrial and environmental monitoring to control emissions and discharges, compliance with sanitary standards in the areas of the enterprise;

- creation of an industry system of economic and environmental audit;

- creation of a system for the declaration of the safety of industrial facilities of the organization and ensuring their insurance protection.

Development of environmental policy, goals and objectives of the company in environmental protection is the first step to creating a system of economic and environmental management. The main functions of environmental policy are:

- setting the goals and activities of the organization;

- compliance with the governing documents for the protection of the environment, the laws, other by-laws, rules and regulations;

- preventing the accidental environmental pollution;

- adjusting to the other aspects of administrative policies, such as product quality, health and safety; specific local or regional conditions.

The programs and plans for implementing the goals and objectives of the economic and environmental policy should be carried out according to the corresponding tasks and plans:

- enterprise budget;

- programs of technical re-equipment and ecological improvement of the enterprise: from current (0.5–1.5 years) to strategic (5–15 years) ones;

- plans of technical re-equipment and equipment with environmental protection machinery;

- plans for environmental training and staff development;

- environmental emergency action plans;

- schedules of making specific actions for the improvement of sectoral environmental management.

The structure of the economic and environmental management system of the enterprise should include the following components:

- resource (financial, material) support;

- organizational support;

- staffing (including job descriptions);

- regulatory and methodological support;

- information support;

- technical support.

The functioning of the economic and environmental management system of the enterprise should be carried out so that the organization should constantly respond to the changing requirements of environmental protection and ensure continuous improvement of the system. In order to improve the organizational and economic mechanism of environmental activities at the enterprise, it is necessary to operate the environmental safety service. It coordinates environmental activities in structural units and monitors the timely issuance of permits and compliance with environmental management limits. At the moment, the main instrument of environmental management are payments for environmental pollution. In most enterprises, the calculation of payments, as well as their coordination with the authorities, are specially authorized for ecology. It is carried out by the Department of environmental protection. The solution to this task has a number of possible approaches to the determination of emissions into the atmosphere as options for ensuring the reliable functioning of economic and environmental systems.

In Russia and abroad there are two different approaches to the definition of emissions and discharges into the environment. This work uses the approach when the concentration of pollutants in water, air and the soil should not exceed the maximum permissible. However, this condition does not affect the company itself – the company should just provide it. This is the contradiction in environmental protection [1, 4, 12]. The enterprise should provide that emissions and discharges that disperse harmful substances to non-hazardous concentrations in certain places. Dispersion of admixtures depends on many factors independent from people (for example, controlling the processes of air displacement). The enterprise should provide the emissions that in any environmental conditions produce the required dispersion of impurities to non-hazardous concentrations.

The western countries make sure that the harmful substances from the enterprise do not have a negative impact on natural ecosystems as a whole. The criterion is

the assimilation potential of the territory that indicated how much toxic substance can be harmfully assimilated by a territory [23]. After determining the amount of harmful substances that can be neutralized within the territory, the company sets limits on emissions and discharges of harmful substances within a certain period. This naturally takes into account the standards of harmful substances concentration in the environment. The discharge or emission quota may be increased only by reducing it for another enterprise, since the amount of these quotas shall not exceed the total discharge for the territory.

It can be concluded that the Western approach is more humane to the environment and the population, and provides a higher quality of the environment - the anthropogenic factors do not go beyond the tolerance of the human body. While following the traditional ways of achieving "absolute" safety and reliability, the company cannot solve the emerging problems and provide the necessary level of security of its facilities. The solution to these problems lies in ensuring an "acceptable" level of risk and risk management, which implies an approach to the accident as a multi-stage process. In the early stages, when there occur an accumulation of negative effects and the destructive action of the initiating phenomenon has not yet been launched, the wise interference into the process of forming a future accident can either completely suppress it or minimize its damage. At later stages, when the accident has already occurred, the prompt response and optimal strategy and tactics of its suppression and protection of people from damaging factors developed in advance would ensure the reduction of human, material, financial, and labor losses [21, 22].

Risk management should be based on in-depth theoretical and experimental studies. Currently, there are common theoretical works on the prediction of risk (accidents). However, they are difficult to apply to the analysis and prediction of specific situations due to the significant unpredictable accidents at gas industry facilities and many factors that should be taken into account [17]. As a result, mathematically correct analysis (from the point of view of the prediction of possible accidents) of even a fairly simple industrial facility requires a large amount of time, and today such analysis can not be carried out by traditional methods. In this regard, the main method of predicting possible accidents is the expert-statistical method. It consists in summarizing the information about the accidents that have already occurred, followed by extrapolation of the results to new facilities [14, 22].

The problem of ensuring the reliability and efficiency of gas production and gas processing systems is the task of economic and environmental management. It should be noted that reliability is the ability of the system to perform the specified functions for a given period of time. Efficiency is also the ability of the system to produce some useful result, that is, when the results of the system exceed the costs of maintaining its work. It is logical to assume that the higher the reliability of the system is, the higher is its efficiency, but the cost of ensuring reliability can be so high that the system becomes inefficient. On the other hand, the desire to minimize costs may result in creating and operating the deliberately cheap and, consequently, unreliable systems [13,21].

Assume that solving the problem of determining the minimum allowable costs while ensuring the maximum possible reliability of the enterprise, one can dispose of a certain set of control parameters for the design and technological performance of the technical system. The vector of control parameters will be a, the set of its permissible values - A. The authors consider the target function to $C(a)$ that characterizes the cost of the technical system. Thus, it is possible to formulate the problem of finding the vec-

tor of control parameters that provides the minimum allowable cost of a technical system while ensuring the maximum permissible reliability standards of this system:

$$\begin{aligned} &C(a) \to \min_a, \\ &P(a) \ge P_0, \\ &a \in A \end{aligned} \tag{1}$$

where P_0 is the minimum value of the reliability index.

If the system allows for the division into interrelated sections (here - the structural units of the enterprise), optimization can be carried out within each subsystem. In this case, there appears a problem of determining the optimal value of the vector of control parameters for the system as a whole and between its subsystems. That is, it is a multicriteria problem of determining the vector of control parameters that provides the minimum allowable cost of the system as a whole and each of the considered subsystems while ensuring the minimum acceptable reliability standards of the entire system and each of the subsystems:

$$\begin{aligned} &C(a) \to \min_a, \\ &C_i(a) \to \min_a, i = \overline{1,N}, \\ &P(a) \ge P_0, \\ &P_i(a) \ge P_{0i}, i = \overline{1,N}, \\ &a \in A \end{aligned} \tag{2}$$

where N is the number of considered subsystems.

It is obvious that the reliability of a complex system varies in proportion to the amount of money invested in its maintenance. It is also obvious that the value of reliability can not increase without limits. That is, having reached a certain value P^*, the reliability no longer changes, no matter how much money is invested in the repair. Therefore, the following task is of practical importance: to determine the available funds allocation for system maintenance (repair, construction of environmental protection facilities, reconstruction of obsolete facilities, etc.), ensuring minimum losses in case of an accident and the maximum possible reliability of both the system and its subsystems. This work also delivers the mathematical formalization of this problem. The whole enterprise will be divided into $Y_i, i = \overline{1,N}$ structural units. Maintenance costs of each unit will be $C_i, i = \overline{1,N}$; obviously

$$C_i^{\min} \le C_i \le C_i^{\max} \tag{3}$$

i.e., the cost of maintenance for each unit should not be less than the minimum allowable costs, providing the minimum required level of reliability of the structural unit, and should be limited from above (due to limited resources of the enterprise). The total amount of money allocated to the maintenance of units should also be limited by the total amount of money allocated to them. That is,

$$\sum_{i=1}^{N} C_i \le C \tag{4}$$

For each unit $Y_i, i = \overline{1,N}$ the authors introduce the values $Z_i, i = \overline{1,N}$ describing the average costs of liquidation of accidents in each of the units. Note that due to limited funds, usually $Z_i \geq C_i^{\max}, i = \overline{1,N}$. Then the value $Z_i - C_i, i = \overline{1,N}$ describes the losses of the enterprise after the maintenance at each of the units $Y_i, i = \overline{1,N}$ in case of an accident - the cost of elimination of damage to the environment, the loss of product, etc. It is obvious that the amount of losses is affected by a number of indicators. Indeed, the same accident will have different consequences depending on the season, the condition of the equipment, etc. Below is a list of parameters that affect the reliability of the system:

- natural and climatic features of the territory where the system is located;

- anthropogenic features of the territory where the system is located;

- parameters of the operational load of the system;

- parameters of protective measures [9, 11].

Each of these parameters, in turn, depends on a number of other parameters. Thus, the real value of losses after the maintenance on each of the units $Y_i, i = \overline{1,N}$ after the accident should be calculated as follows:

$$(Z_i - C_i)k_i^1 k_i^2 k_i^3 k_i^4 \qquad i = \overline{1,N} \tag{5}$$

where each coefficient $k_i^j, j = \overline{1,4}, i = \overline{1,N}$ describes the effect on j-parameter listed above in the i unit. The value of this coefficient is a generalized value that takes into account the influence several indicators. The total amount of losses from all accidents is calculated as follows:

$$\sum_{i=1}^{N}(Z_i - C_i)k_i^1 k_i^2 k_i^3 k_i^4 \tag{6}$$

As it was noted above, the probability of failure-free operation was seen as a function from the funds invested in maintenance. Reliability of the enterprise can be calculated as the total reliability of each of the considered subsystems $Y_i, i = \overline{1,N}$, that is

$$P(C) = \sum_{i=1}^{N} P_i(C_i) \tag{7}$$

where $P_i(C_i)$ - the reliability of each of the subsystems, $P(C)$ - the reliability of the whole system. Note that $P(C)$ can be calculated inversely proportional to the total amount of losses from accidents. The authors consider the control parameters to be the funds invested in the maintenance of each of the units, that is $C_i, i = \overline{1,N}$. The authors make a record of the task:

$$\begin{gathered}
\sum_{i=1}^{N}(Z_i - C_i)k_i^1 k_i^2 k_i^3 k_i^4 \to \min_{\sum_{i=1}^{N} P_i(C_i) \to \max} \\
C_i^{\min} \leq C_i \leq C_i^{\max}, i = \overline{1,N} \\
\sum_{i=1}^{N} C_i \leq C \\
P_i(C_i) \geq P_o, i = \overline{1,N}
\end{gathered} \tag{8}$$

This task is multi-criteria and its solution, due to its limits in the material resources allocated to the maintenance of structural units in practice, is non-trivial. To solve the problem (8), the following method should be used:

a) the N sample points are randomly selected; the criteria values are calculated in them (6), (7);

b) then the points that do not satisfy the restrictions are excluded (3), (4);

c) to highlight the set approximate to Pareto optimal, the authors perform the algorithm exception of definitely worst points: first they choose a point from the set of possible solutions and mark it. Comparing it with all other points, the authors exclude the points that are obviously worse than this from the set of acceptable solutions. Then, they choose any unmarked point from the remaining points and compare it again with all the points, excluding the definitely worst, then mark it. After a finite number of steps, only the marked points remain. All of them will be approximately efficient.

The calculation was carried out in the mathematical software MathCad 2000 PRO and in the program written in Borland Pascal 7.0. The MathCad document generates numerous sample points, calculates the criteria values, and records them into a file. The program reads data from a file, selects a set of Pareto-optimal points, and saves them to another file. The MathCad document reads this set and builds a graphical representation of the Pareto area. Source data:

- $Y_i = Z_i - C_i, i = \overline{1,5}$, losses of the five main units of the company in case of an accident;

– $P_i(C_i) = 1 - \frac{a_i}{C_i - b_i}, i = \overline{1,5}$, empirical dependencies of the probability of failure-free operation P_i on the funds invested in the maintenance; a_i, b_i, coefficients obtained as a result of statistical analysis of the enterprise functioning;

– $Z_i, i = \overline{1,5}$, average costs for liquidation of accidents in each of the units in case of an accident. The values are obtained according to the statistics;

- $k_i^j, j = \overline{1,4}, i = \overline{1,5}$, characterizes the influence of j parameter on the probability of failure-free operation of i unit. The values are obtained as a result of expert analysis of the enterprise functioning;

- P_o, minimum acceptable standard value of reliability;

– the maximum permissible maintenance costs of each unit $C_i^{\min}, C_i^{\max}, i = \overline{1,N}$, determine the set of valid values $C_i, i = \overline{1,5}$. The values are derived according to the statistics.

Results:

- a set of Pareto-optimal points is determined (Fig. 1). The practical testing of 250 test points determined the area of the unimprovable values (the Pareto area) in tabular form;

- the authors found the solutions providing maximum reliability - the solutions that provide a minimum allowable cost of maintenance of the system.

As it can be seen from the calculations, the total average reliability reaches a maximum value of 0.906 at a total cost of 175541.8 (which is less than the maximum allowable amount of maintenance costs of the system).

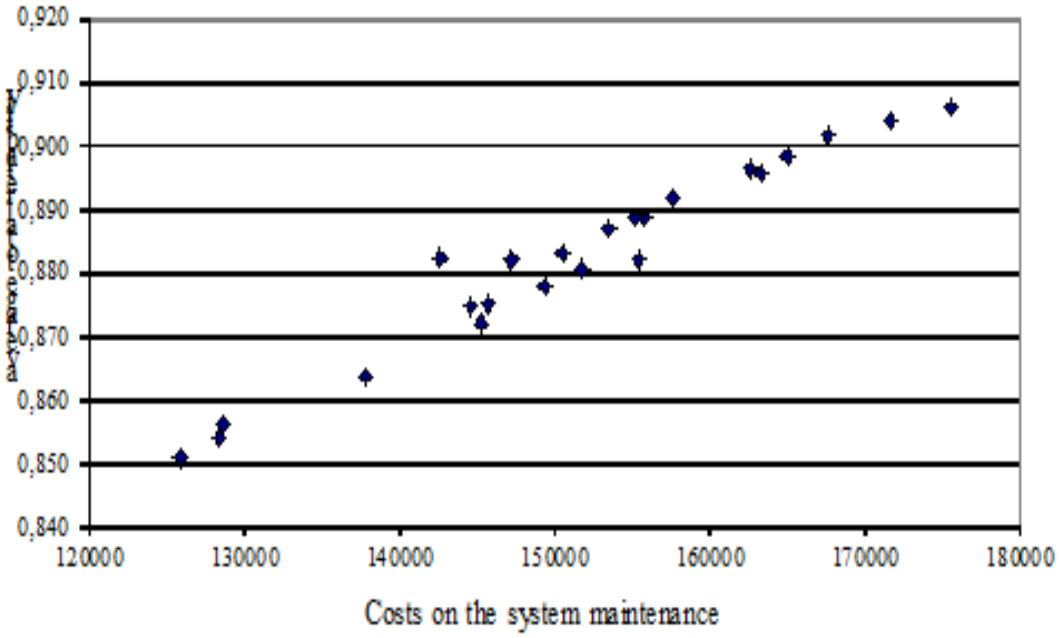

Figure 1-The results of solving the problem of ensuring the minimum allowable costs for environmental protection measures with the maximum possible reliability of the system with equivalent criteria

3. CONCLUSION

The proposed method of cost optimization of environmental measures in the ongoing restructuring to ensure the maximum total reliability allows a more rational funds distribution. The methodological guidelines of resource optimization based on the implementation of the task (8), proposed in this paper, as well as recommendations on the formation of economic and environmental subsystem in the enterprise management system, will allow managers to choose the most efficient actions, depending on the situation, while providing the necessary level of reliability of the enterprise with a sufficient level of reserves.

The scientific novelty of the work is as follows:

- the concept of economic and environmental support for restructuring of the enterprises in the transition economy was developed and proposed using the analysis of scientific and technical literature;

- the formulation, formalization and implementation of the problem of distribution of costs for environmental measures to reduce environmental risks of the enterprise using the apparatus of mathematical programming, in particular, vector optimization (Pareto set) were developed and proposed.

The practical significance of the work lies in the fact that on the basis of theoretical, methodological and practical recommendations, it is possible to improve the efficiency of economic and environmental support of the enterprise.

REFERENCES

[1] Alieva, T.E. (2011). Economic factors of restructuring the management of a mining enterprise [Ekonomicheskie faktory restrukturizatsii upravleniya gornopromyshlennym predpriyatiem]. European Social Science Journal, 13, 413-420.
[2] Aistova, M.D. (2002). Enterprise restructuring; management issues. Strategies, coordination of structural parameters, reducing the resistance to transformations [Restrukturizatsiya predpriyatiy; voprosy upravleniya. Strategii, koordinatsiya strukturnykh parametrov, snizhenie soprotivleniya preobrazovaniyam]. Moscow: Al'pina Pablisher, 287p.
[3] Buzgalin, A.V. & Kolganov, A.I. (2003). The theory of socio-economic transformations. Past, present and future of the economies of "real socialism" in the global post-industrial world [Teoriya sotsial'no-ekonomicheskikh transformatsiy. Proshloe, nastoyashchee i budushchee ekonomik «real'nogo sotsializma» v global'nom postindustrial'nom mire]. Moscow, TEIS, 656p.
[4] Borodin, A.I. (2004). Environmental factors in the creating market strategies of the enterprise [Ekologicheskiye faktory v sozdanii rynochnykh strategiy predpriyatiya]. Vestnik Dagestanskogo nauchnogo tsentra RAN,19, 173-177.
[5] Bil'chak, V.S. & Borodin, A.I. (2009). Formation of a sustainable development of an enterprise in a region: mechanisms, methods, management (environmental and economic aspect) [Formirovanie ustoychivogo razvitiya predpriyatiya regiona: mekhanizmy, metody, upravlenie (ekologo-ekonomicheskiy aspekt)]. Kaliningrad: RGU im. I. Kanta 185p.
[6] Bobylev, S.N. & Khodzhaev, A.Sh. (2010). Environmental economics [Ekonomika prirodopol'zovaniya]. Moscow: Izd-vo INFRA-M.
[7] Borodin, A.I. (2012). Economic and environmental programming of sustainable development of the region [Ekonomiko-ekologicheskoe programmirovanie ustoychivogo razvitiya regiona]. LAP LAMBERT Academic Publishing GmbH & Co. KG, 432p.
[8] Borodin, A.I. (2005). Formation of environmental policy in Russia [Formirovanie ekologicheskoy politiki v Rossii]. Vestn. Kyrgyzsko-Rossiysk. Slavyansk. un-ta, 2, 124-126.
[9] Bobylev, S.N. & Stetsenko, A.V. (1999). Economic evaluation of natural resources and services [Ekonomicheskaya otsenka prirodnykh resursov i uslug]. Ekonomicheskiy vestnik MGU, 211p.
[10] Bystrakov, Yu.I. & Kolosov, A.V. (1988). Economics and ecology [Ekonomika i ekologiya]. Moscow: Agropromizdat, 204p.
[11] Voznyak, V.Ya., Feytel'man, N.G., Arbatov, A.A., et al. (1994). Ecological recovery of the economy [Ekologicheskoe ozdorovlenie ekonomiki]. Moscow: Nauka, 224p.
[12] Glukhov, V.V., Lisochkina, T.V. & Nekrasova, T.N. (1997). Economic bases of ecology: Coursebook [Ekonomicheskie osnovy ekologii: Uchebnik]. Saint Petersburg: «Spetsial'naya Literatura», 304p.
[13] Golub, A.A. & Strukova, E.B. (1999). Economics of natural resources: university coursebook [Ekonomika prirodnykh resursov: Ucheb. posobie dlya vuzov]. Moscow: Aspekt Press, 319p.
[14] Goncharuk, T.I. & Semenenko, T.V. (1999). Ecological and economic aspects of management of industrial enterprises [Ekologo-ekonomicheskie aspekty upravleniya promyshlennymi predpriyatiyami]. Problemy teorii i praktiki upravleniya, 1, 83-97.
[15] Danilov-Danil'yan, V.I., Losev, I.E. & Reyf, I.E. (2005). Before the main challenge of civilization. A view from Russia [Pered glavnym vyzovom tsivilizatsii. Vzglyad iz Rossii].

Moscow: INFRA-M, 224p. URL: http://lit.lib.ru/r/rejf_i_e /peredglawnymwyzowomciwilizacii.shtml#закладка.
[16] Danilov-Danil'yan, V.I. (n.d.). Key factor in the economic development [Klyuchevoy faktor razvitiya ekonomiki]. URL: http://viperson.ru/wind.php?ID=499372&soch=1.
[17] Kuz'min, I.I., Makhutov, N.A. & Khetagurov, S.V. (1997). [Bezopasnost' i risk: ekologo-ekonomicheskie aspekty]. Saint Petersburg: Izd-vo SPbGUEF, 164p.
[18] Kryzhanovsky, V.G. (1998). Restructuring of the enterprise. Compendium of lectures [Restrukturizatsiya predpriyatiya. Konspekt lektsiy]. Moscow: Izdatel'stvo PRIOR, IVAKO Analitik, 48p.
[19] Mukhtarova, E.G. (2002). The essence of the economic damage from environmental pollution [Sushchnost' ekonomicheskogo ushcherba ot zagryazneniya okruzhayushchey prirodnoy sredy]. In: Ekologicheskaya politika i ustoychivoe razvitie regionov Rossii: proceedings of the All-Russian research and practice conference. Ed. Vdovina, Yu.I. Penza: Izd-vo Privolzhskiy Dom Znaniy, 89-91.
[20] Pashin, S.T. (2000). Economic and environmental management in corporations [Ekonomiko-ekologicheskoe upravlenie v korporatsiyakh]. Ufa: Izd. Fonda sodeystviya razvitiyu nauchnykh issledovaniy, 111p.
[21] Rodionova, L.N. & Mukhtarova, E.G. (2001). Market orientation of regional environmental management [Rynochnaya oriyentatsiya metodov ekologicheskogo upravleniya v regione]. In collected works: Ekonomicheskiy vestnik UGNTU. Eds. Rodionova, L.N. et al. Ufa: izd-vo Fonda sodeystviya razvitiyu nauchnykh issledovaniy, 105-110.
[22] Sadekov, A.A. (2002). Mechanisms of environmental and economic management of the enterprise [Mekhanizmy ekologo-ekonomicheskogo upravleniya predpriyatiyem]. Donetsk: DonGU-ET im. Tugan-Baranovskogo, 311p.
[23] Serditova, N.E. (2008). Analysis of complex environmental and economic systems: thermodynamic approach [Analiz slozhnykh ekologo-ekonomicheskikh sistem: termodinamicheskiy podkhod]. Uch. zap. RGGMU, 7, 138-154.
[24] Taylor., B. (1995). The new strategic leadership - driving change, getting results. Long range planning. Oxford etc., 5, 71–81.
[25] Khammer M. & Chempi, Dzh. (1997). Corporation reengineering: a manifesto of the revolution in business [Reinzhiniring korporatsii: manifest revolyutsii v biznese]. Izdatel'stvo S.-Peterburgskogo universiteta, 365p.[26]Trenev, V.N., Irikov, V.A., Il'demenov, S.V., Leont'ev S.V., Balashov V.G. (1998). Reform and restructuring of the enterprise. Methodology and practices [Reformirovanie i restrukturizatsiya predpriyatiya. Metodika i opyt]. Moscow: Izdatel'stvo PRIOR, 320p.