

# Problems of modern technological audit of mining enterprises

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**Abstract.** Modern economic conditions are characterized by spontaneous changes in market conjuncture, by accelerating the pace of scientific and technological progress in industrial production, which tightened the requirements for production activities, economic and organizational management of domestic enterprises. Currently, the most competitive products in the world market are the products of extractive industries, which determines the increased attention to the problems of the functioning of these industries and the clarification of the conditions of their most sustainable development. The unique mineral resource complex of Russia can provide further economic development of the state only on condition of effective activity of the largest mining enterprises. It is important to adapt enterprises to the changing environment, which imposes new planning requirements, on the basis of which not only forecast indicators are calculated, but also the possibility of improving the competitiveness of the organization.

## 1. Introduction

The need for an effective state industrial policy aimed at the modernization of mining production requires the development of such methods of determining and implementing the main directions of development of engineering and technology as technological audit.

Systematic changes in the volumes of production work in the space and time, variability of the characteristics of the volumes of the development and phasing of obtaining geological information about these characteristics, change in time (due to the duration of mine development) of applied technical means and economic conditions of mining operations determine the complexity of their structure, specific combinations of elements for mining technology, which are diverse in terms of purpose and functioning.

At the same time, along with the positive aspects (dynamism, flexibility, adaptability), the inertia of geotechnology as a system requires a long time to optimize it.

In this case, the project examination should be considered as the first stage of the technological audit of the enterprise, assessing the overall implementation of the project in the Annex to the specific conditions and the ability of the mining enterprise (ME) to its introduction, the efficiency of subsoil use and ensure the required level of industrial safety.

Periodic technology audit allows to solve problems such as determining the optimal

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transition point between stages of mining development (including prior adjustments of implemented project solutions) and improving the efficiency of existing technological scheme at an ME and parameters of mining operations by considering the influence of factors of organizational structure of the production processes management (including mainstreaming these issues while designing an ME).

At the same time, in the conditions of market relations, the practical task of the miners is to find such a ratio of the size of the field and the production capacity of the ME, and the associated choice of the opening method, the development system, equipment and technology of mining operations on it, in which the costs necessary to obtain commercial products would be justified in the shortest possible time.

## **2. Theory**

Developing a practical focus on potential mining sciences, in turn, puts the task of developing mechanisms and methods of evaluation the functioning of the ME from the perspective of use in its work the latest achievements of science and practice as beginning with an analysis of the design parameters of the quarry (for example, the study of the possibility of a steeper pit edge construction), and in part of the most urgent environmental issues on the agenda:

1. Finding ways to maximize the possible introduction of non-waste technology of mining (where as a criterion describing the social utility can be used an indicator of the share of productive use of the extracted rock mass, including reduced to the total value of the products obtained from it).

2. Ensuring acceptable environmental safety of their processes (for example, the use of the method of determining and accounting for the energy factor and the amount of environmental payments in the justification of the choice of type and means of open-cut transport).

Along with the definition of promising tasks of technological development in assessing the effectiveness of the ME, it is necessary to pay due attention to the nature of the current processes of the enterprise vital activity. The main event that can provide at the current level of financial capacity of the enterprise its stable operation is the mobilization of its internal reserves (saving of material and energy resources, improving the use of equipment, ordering of wages and other), the search for which is one of the main directions of technological audit. We note the coincidence of this statement of the issue with the opinion of the experts of the international program TACIS (Technical Assistance for the Commonwealth of Independent States) that the very existence of the ME depends on how well it will be able to resist the cost of its production. In this case, an important role in the implementation of this approach to the solution of the problem plays the definition of marketable and technologically possible (in the current mining, geological, technical and economic conditions) productivity of the ME at the present moment. Today, the methods of reliability theory are widely used in the calculation of mining and transport equipment, process lines. In assessing the reliability of the quarry, it is usually considered in the form of a set of overburden and mining ledges with various reserves between them and technological processes, damped reserves of smoked and blasted rock mass. In this case, the calculation of reliability uses its statistical and physical theory, the methods of which can not be directly transferred to calculate and ensure the reliability of a quarry, which is a complex socio-economic system.

One of the main aspects of the performance evaluation of the ME, directly related to the state of its technological systems is the assessment of staff productivity. In modern conditions of functioning of the Russian mining enterprises, productivity increase becomes a means of achievement of balance of interests of owners of the capital and

labour, expressed in increase in business value and the price of labour, and also in creation of preconditions for economic growth.

At the same time, it should be noted that the principles of the organization of production in most MEs remain the same - corresponding to the conditions when the growth of labor productivity was considered only as a means of increasing production. This discrepancy has led to the fact that the organizational system of the enterprise has often become a factor hindering its development as a business unit. (As a rule, the measures for equipment reconstruction at the mining enterprise are associated with an increase in production volumes, and in rare cases, with a reduction in production costs).

Since the processes of open-pit mining have been described to a satisfactory degree by now, in order to find reserves for further improvement of their efficiency within the boundaries of the technological schemes used at the ME, in modern economic conditions, it is competent to transfer the focus of the main directions of further research of the mechanisms of functioning of the ME to assess its efficiency, study of the interaction and relationships of the processes of mining operations from the point of view of the functioning of the unified logistics system, in particular, taking into account the impact on its performance and effectiveness of organizational structures as mining management, and the overall organization of the functioning of the ME. Thus, increasing the overall efficiency of mining production and, consequently, improving the competitiveness of the mining enterprise in the market, is the main task of research on the analysis and evaluation of technological systems of the MEs with their mandatory emphasis on the organizational aspects of the ME vital activity.

As an example of a list of such studies of a similar nature and urgent, from the point of view of mining practice, problems of implementation of the stated task can be given:

In the field of technological solutions:

1. Minimization (in the absence of reliable long-term forecasts on the prices of the domestic market for mineral raw materials) of rationing the amount of advance of overburden works, as well as opened and ready to excavate mineral reserves with a shift to the focus on the regulation of methods and parameters of the formation of the working area of mining.

2. The transition in the planning of mining operations from the definition of calendar plans of their development to the construction of conjuncture conditioned stages of formation of the working area of excavation with the mandatory accounting changes in the quality of extracted minerals in determining the mode of staged mining operations, including the temporary preservation of opportunistic low-gain (on a lower level of provision in the period considered simple reproduction) reserves. In this regard, it is advisable and necessary to make legal adjustments to the provisions on their selective testing.

3. Ensuring the management decision-making on the formation of stages of mining operations in the development or correction of the project of the ME by mechanisms of adequate assessment of production performance of the enterprise from the point of view of rationality in the period in question, used in the last technological schemes and parameters of mining processes, and the very reliability for such an assessment and the adequacy of these indicators to justify the decisions (including in terms of compliance with the organizational structure of its technological potential).

In the field of state control over mining operations:

1. Determination of the role and status of technological audit in relation to state supervision (for example, the system of expertise), the principles of division of their competence and powers with the simultaneous integration of areas of their work to ensure the efficiency of the ME, the methodology of accounting for the specific features of the latter by analyzing the need and sufficiency to ensure industrial safety of the

requirements put forward to them, including the use of the apparatus for accounting for possible risks of their activities.

2. Definition and formalization of mechanisms for certification of mining processes (including in accordance with the requirements of the "Technical regulation" Act), aimed primarily at improving the efficiency of economic activity of the mining enterprise by reducing possible damage from injuries of personnel and accidents at the facilities.

In the field of environmental safety:

1. Development of evaluation criteria for the expansion of environmental impact effect and environmental audit of existing MEs by analyzing the performance of enterprises of their environmental programs and the focus (sufficiency) of their technological processes for the full extraction and use of the extracted minerals and rock mass as a whole.

2. Analysis of the technologies used by MEs in terms of identification of their aspects causing negative impact on the environment (including ranking of technologies according to the degree of their environmental danger) and socio-economic justification of measures to neutralize them, also taking into account the long - term prospects of development (as an example-the feasibility of the biological phase of remediation of sludge storage as potential man-made deposits).

3. Determination of mechanisms and conditions for tax and other benefits for the ME (including determination of their composition and size) to stimulate the implementation of environmental programs, including those aimed at obtaining a positive effect in the long term.

World practice shows that the impact of negative factors of the production activity in case of occurrence of various emergency situations depends not only on the level of technology, but also on the quality of the associated management systems, which are aimed primarily at managing the planning process and the achievement of relevant technology processes objectives in the area of production indicators, while ensuring reliability and safety of the processes themselves.

Naturally, any system (and even more so - technological) can be considered effectively functioning only if its continuous improvement is ensured, which, in turn, is achieved through constant analysis and evaluation of its quality. The audit is directed to obtain information for further analysis and correction of the system.

### 3. Results

Thus, *technological audit* is the diagnosis (through the analysis of the technological system) of the enterprise operation in order to identify its increases in production costs. At the same time, a distinctive feature of the process of technological audit is its dynamic nature, unlike control (supervision) or expertise. At the same time, depending on the tasks assigned to the technological audit, the control (examination) and examination procedures can undoubtedly be included in the process of technological audit as one of its stages. It should be emphasized that the technology audit is aimed at assessing the quality and effectiveness of the system as a whole (including its organizational structure), and not to search for specific violations. Any violation in this regard should be considered not as a separate fact, but as a key to finding a discrepancy either in the structure of the system itself or in the process of its implementation. The task of the audit is to find the causes of inconsistencies, the elimination of which will minimize deviations from the project regulations.

Therefore, the process of technological audit is a broader concept in comparison with the traditionally used methods of assessing the activities of enterprises, as not only formulates ("records") the state of their production systems, but also (through the

analysis of the enterprise's capabilities) allows to develop (offer) recommendations for improving the efficiency of the enterprise. In addition, the process of technological audit allows to investigate and evaluate the criteria of evaluation of the enterprise, including the requirements imposed on them by the external environment for their justification and completeness in the specific conditions of the enterprise (to determine their "applicability").

Methodically complex technological audit of the enterprise functioning, including along with economic indicators of its activity the criteria characterizing the state of mutual influence of the external environment and technological system of the enterprise, obviously, must meet the following requirements:

1. Provide an assessment of not only the level of material production and opportunities for the implementation of its development prospects, but also closely related issues in the field of industrial safety, environment, organizational management structures, personnel development and, in general, the community of the enterprise location.

2. Ensure the comparability of the results of the assessment of the state of domestic enterprises, both in the national and international market.

Based on the above conditions and objectives of the technological audit, as the main methodological principles of its construction as a process can be identified:

1. Consistency as periodicity and schedule obligations and certainty on the procedures of the study.

2. Objectivity as independence in evaluation and validity according to its criteria, including social positions.

3. Adaptivity as adequacy of the applied research methods to the conditions of construction and organization of technological systems, "sensitivity" to their changes and options, including in relation to the conditions of the external environment of the enterprise.

4. Sufficiency as validity of the depth of research and the scale recommended in its conclusion activities, the establishment of the range of requirements (analyzed) in the audit of the enterprise and their inventory on mandatory and optional ones.

Thus, the main tasks in the field of technological audit, taking into account international practice can be attributed to:

1. Obtaining reliable information about the activities of business entities in the field of functioning of their production systems, increasing their competitiveness in the world market by improving these systems, improving environmental and industrial safety of the latter.

2. Assistance to business entities in the independent regulation of their industrial policy, the formation of priorities for the implementation of preventive measures aimed at maintaining and improving production systems in a changing environment.

3. Reduction of financial risk of business entities, insurance and financial-credit organizations.

4. Creation of a tool for the implementation of the main directions of production process regulation.

5. Integration of activities in the field of technological systems improvement with other areas of activity of enterprises, the introduction of efficiency evaluation of their production systems.

6. Taking into account and applying universally recognized international principles, methods and procedures.

7. Training and involvement of competent specialists in technological design and audit.

Hence, the results of technological audit of production systems should become an objective economic and legal tool to stimulate the economic activity of the enterprise, as it is known that no "straight-line" tightening of requirements for the enterprise can provide its "ideal" work, it will only lead to the inhibition of its processes.

Compulsory technological audit should be performed:

1. In the implementation of international obligations in the field of technical regulation of production processes.
2. On behalf of the state bodies, including justification of possible sanctions against the enterprise.
3. To take into account the technological factor in the privatization of state and municipal enterprises.
4. In the implementation of the bankruptcy proceedings of economic entities.
5. When carrying out mandatory risk insurance.
6. In the preparation and justification of investment projects and programs (when it is provided by the terms of investment), etc.

Mining enterprises as objects of design, construction, operation and management (including auditing, as one of the management tools) belong to the highest category of complexity and are characterized by large amounts of information of various kinds:

1. Geometric, including elements of the deposit and mining technology, considered in the three-dimensional space of the mining branch.
2. Economic, containing indicators and estimates of resource costs, indicators of product value, intensity and efficiency of work, etc.
3. Technological and technical, including parameters and quality characteristics of elements of mining, mining and transport equipment and technological processes.
4. Environmental, reflecting the interaction of technological processes of mining and natural factors, such as subsoil, earth's surface, the surrounding atmosphere, water resources.
5. Social, including the performance and characteristics of industrial danger of technological processes of mining production.

## **4. Outcomes**

1. Improving the overall efficiency of mining production and, consequently, improving the competitiveness of the mining enterprise in the market, is the main task of research on the analysis and evaluation of technological systems of the mining enterprise with their mandatory emphasis on the organizational aspects of the vital activity of the mining enterprise.

2. A technological system can be considered to be effective only if it is continuously improved, which in turn is achieved through continuous analysis and evaluation of its quality.

3. The results of the technological audit of productive systems should become an objective economic and legal tool to stimulate economic activity of the enterprise.

4. The proposed approach to the mining audit methodology allows, on the one hand, to clearly comply with the requirements of state supervisory bodies, on the other hand, it allows to respond flexibly to the emergence of new technologies and new equipment. In fact, on this basis, it is possible to implement the state industrial policy aimed at the modernization of the existing mining industry.

## Reference

1. Gusev A.I., Kovalev M.N. Improvement of the industrial safety system. *Industrial safety*. **12**. P. 2-6. (2003).
2. Gusev A.I., Kovalev M.N. Mining information and analytical bulletin. Published by MGGU. **3**. p.22. (2004).
3. Mining audit and development of the concept of development of mining and processing production (MPP) of JSC "Kombinat Magnezit". Phase 1. Mining audit of technical and economic solutions in the system of MPP: NIR report. / OAO «Kombinat Mgnezit, OOO NVTs «Nedra» - Chelyabinsk, Satka. 101 p. (2002).
4. Pevzner M.E. Mining audit. Textbook for higher school. 3-d edition. Published by Moscow State Mining University. 215 p. (2004).
5. Technological audit act on the Kvaisinskiy inderground mine, developing Volkhokhskiy plot of the Kvaisinsk lead-zink ore deposit, Tskhinval. Ekaterinburg. 74 p. (2012).
6. Anikin A.V., Vorobiev A.E. Mining and technological audit of the gold mining company JSC " Vasilevsky mine». Published by MISIS. (2013).
7. Vorobiev A.E., Danilova E.V. *Vestnik RUDN, Engineering research series*. **4**. (2013).
8. Sobolev A.O., RF subsoil use expert. Geological audit according to international standards and problems of mining and geological industry in Russia. *Gold mining*. **178**. (2013).
9. GOST R 57194.3-2016 Technology transfer. Technological audit.
10. Chetverik N.P. Technological audit and construction control: educational manual. Moscow: ANO DPO «APKIRK». 354 p. (2017).