

L. Savchuk¹,
 orcid.org/0000-0003-2603-7218,
 L. Bandorina¹,
 orcid.org/0000-0003-1383-3098,
 K. Udachyna¹,
 orcid.org/0000-0002-0043-6010,
 V. Savchuk²,
 orcid.org/0000-0001-6750-9221,
 R. Savchuk¹,
 orcid.org/0000-0002-3336-6565

1 – National Metallurgical Academy of Ukraine, Dnipro, Ukraine, e-mail: eudachina7@gmail.com
 2 – Dnipro University of Technology, Dnipro, Ukraine

FORMATION OF STRATEGY FOR MANUFACTURING SYSTEM OF THE MINING AND METALLURGICAL ENTERPRISE ON THE TRIAD-BASED PRINCIPLE

Purpose. Formation of the strategy of a mining and metallurgical enterprise taking into account the competitive advantages of the manufacturing system to increase the efficiency of its operation.

Methodology. The basis of the study involved: methods of theoretical generalization for clarifying the definitions: “behavioral characteristics”, “usefulness”, “adaptation”; expert method – for evaluating and ranking the input parameters of the system formation of strategy for manufacturing system; modern information technologies (MS Visual Studio programming environment) for software module development.

Findings. An algorithm for evaluating the usefulness and adaptation of behavioral characteristics for manufacturing system based on the triad principle is presented. A strategy for manufacturing system based of built tactics by identifying record, potential, weak and risky aspects of behavioral characteristics is formed. A software module is developed that provides recommendations for the received calculations.

Originality. Methodological approach to assessing the characteristics for manufacturing system of the mining and metallurgical enterprise on the principle of the triad is improved, which, in contrast to the existing ones, allows taking into account three points of view of evaluation: with regard to the object of management (self-regulation model), with regard to the branch body (management model); from the standpoint of the state regulatory body (control model), which allows identifying competitive advantages due to the behavioral characteristics of the manufacturing system.

Practical value. The proposed evaluation model based on the triad is universal and can be used in the practical work of economic entities, which will increase the efficiency of their operation and ensure targeted activities aimed at making informed and timely decisions.

Keywords: *strategy, production system, triad, evaluation positions, adaptation, behavioral characteristics*

Introduction. The mining and metallurgical sector (MMS) of Ukraine provides a significant part of GDP and acts as a raw material base for mechanical engineering, transport and construction industries. The power of this industry is due to the availability of Ukraine’s own raw material base. However, today, given the current economic and political situation, there is a negative trend of development of mining and metallurgical enterprises.

In modern economic conditions, mining and metallurgical enterprises face the urgent issue of adapting to the market environment, assessing their strengths and weaknesses for competition and effective operation. Therefore, an important task is to determine further actions taking into account the competitive advantages within a particular strategy.

Literature review. Among the approaches to determining the prospects for strategic development of the mining complex the strategic competitiveness analysis can be identified, which allows building appropriate corporate strategies and operational processes for their implementation at the enterprise, industry and government in general [1].

The issues of development of the mining and metallurgical industry in the post-crisis period were studied by Stalinska O. and Volochko G. [2], and the basic principles of the MMS strategy were considered.

Wenger V.V. proposed the State Program of Modernization and Development of the Metallurgical Industry, where he singled out the optimization of metallurgical capacities, devel-

opment and implementation of an innovative model of industry development, development of metal product sales markets, improvement of state policy on metallurgy industry development among the main tasks [3].

Kyrychenko O. O. emphasized the cardinal modernization of fixed assets of the mining and metallurgical sector (MMS) of Ukraine, the optimization of production processes and the expansion of the product range [4].

Prospects for the development of the metallurgical industry of Ukraine are considered in [5], where the authors analyze the production, export-import of metallurgical products and propose the main ways to overcome problems and achieve further sustainable development of the metallurgical industry of Ukraine.

Melnyk O. V. noted that it is important to combine new materials (alloys) with unique properties in specific products and the use of a global platform to promote their products and services [6].

Kulitsky S. studied the state and problems of development of domestic metallurgy, taking into account the political factors of influence [7].

Afanasyev Ye. V. and Nusinov V. Ya. within the key tasks of the “National program of SME development of Ukraine for the period up to 2030” [8] considered the multi-criteria and multivariate strategic planning of MMS enterprises; proposed measures to improve the direction of technical and economic development of mining enterprises in order to ensure maximal efficiency of the economic potential of MMS of Ukraine in conditions of uncertainty and conflict of the market environment [9].

Shulgina L. M. and Yukhimenko V. V. improved the process of building strategies for innovative development of mechanical

Table 1

Modified Harrington scale to assess the severity level of usefulness and adaptation of indicators

Item	Evaluation interval	Severity level of usefulness and adaptation of behavioral characteristics
1	$0.8 \leq D < 1$	Very high
2	$0.63 \leq D < 0.8$	High
3	$0.37 \leq D < 0.63$	Average
4	$0.2 \leq D < 0.37$	Low
5	$D < 0.2$	Very low

engineering enterprises by developing a theoretical-game model and a strategic map based on a process approach [10].

The logistical approach [11], which identifies strategic priorities to increase the competitiveness of industrial enterprises, can be also identified among the research tools.

Unsolved aspects of the problem. Given the scientific and methodological approaches to determining the strategy of the mining enterprise, the issue of assessing the production system of a legal entity not only at the level of the management object, but also in terms of sectorial and state regulation remains unresolved.

The purpose of the article is to form a strategy for the production system of a mining enterprise, taking into account its competitive advantages.

Methods. To ensure stable data effectiveness, it is proposed to evaluate the production system of the enterprise from three points of view, according to the principle of the triad. Evaluation is performed by:

- the object of management (model of self-regulation);
- industry authority (management model);
- state regulatory authority (control model).

An important step in the analysis of a particular system is the formation of the evaluation base. There are the following criteria of the production system:

- production rhythmicity;
- intensity of equipment operation;
- integrated use of resource base;
- quality of materials;
- rates of consumption of material resources per a product unit;
- balanced operation of production facilities;
- expansion of cooperation;
- change in equipment suppliers.

Indicators in this case are evaluated as behavioral characteristics in terms of usefulness and adaptation. Each party takes into account the usefulness of the indicators they bring to the entity at a particular level: government, industry or enterprise.

The level of adaptation of certain criteria is assessed by the representative of state regulation within the macro-environment, i.e. their adaptation to the impact of economic (consumer income, price of tourist product, exchange rates), geographical (place of residence, climatic conditions, pollution and industrialization), political (changes in tax legislation, the size of state budgets, government regulation, ensuring economic independence, strengthening defense capabilities), cultural (views, social position, religion, family traditions), demographic (gender, age, education), scientific and technical (introduction of new equipment and technology) and environmental (state of environmental pollution) factors.

At the industrial level, the criteria are assessed within the micro-environment, i.e. the adaptation of indicators to competitors, credit and financial institutions, the consumer market, intermediaries and suppliers.

The head of the enterprise evaluates the behavioral characteristics within the business entity, taking into account their adaptive capabilities to internal factors of influence (organizational structure, staff, costs, profits, innovation and investment opportunities).

Estimates are based on the Harrington Desirability Scale (Table 1), which is universal and can be used to evaluate many modifications of qualitative indicators. This scale is based on the uneven distribution of criteria and provides a combination of numerical and verbal assessment indicator [12].

After that, the scores are transferred into a scale, the indicators are sorted by the level of usefulness and adaptation in descending order.

Graphically, the evaluation of criteria is proposed to be represented on the Cartesian coordinate system. The plane is divided into four quadrants, on which the level of adaptation expression (R_y) is plotted along the Y axis, and the level of utility expression (R_x) of the criterion of the evaluated system is plotted along the X axis (Fig. 1).

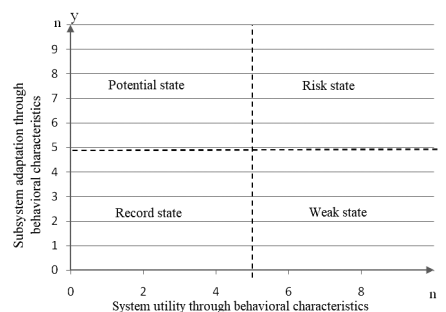


Fig. 1. Distribution of quadrants of an enterprise activity: record state, potential state, risk state, weak state

The first quadrant “Record state” includes behavioral characteristics, whose record values maximally characterize this legal entity’s system. That is, these are certain advantages that distinguish this company in the best way in the mining and metallurgical industry. Positioning in accordance with the usefulness of the enterprise characterizes the satisfaction of highest needs and, in this sense, it is the attention to these characteristics of the enterprise that motivates its effective activity. Thus, this quadrant determines the power of the production position of the enterprise and a high degree of adaptation to environmental conditions.

The second quadrant “Potential state” includes indicators that are potentially able to benefit the entity, but the property of adaptation to the factors of influence in them is weakly expressed. These are the potential opportunities that the company is ready to use in special cases. And, if to increase the level of their significance in the modeling of the company’s activity, there are new motivators for the effectiveness of its activities. Thus, this quadrant allows determining the parameters that contribute to the opening of new opportunities in development.

The third quadrant “Risk state” includes those indicators that are not only weakly expressed in the structure of the evaluated system, but also characterize its weak ability to adapt to external factors. These are the criteria that deserve special attention and require special skills, knowledge and effort.

The fourth quadrant “Weak state” includes those indicators that mean a high level of adaptation of the entity’s production system to environmental conditions, but which are currently less useful than other indicators. The development of these criteria is supported by a natural process due to the development of other more significant qualities in the activity. Thus, this quadrant means the weak point of the production system, that is, the company seeks to be more efficient in the relevant parameters, but in reality is not yet able to do so.

It is proposed to determine the coordinates of the behavioral characteristics of each quadrant according to the formulas

$$R_{A_{min}}^{k_q} [j] = R_{A_i}^{k_q}, \text{ if } R_{A_i}^{k_q} \leq \frac{n}{2}; \quad q = 1;$$

$$R_{U_{\min}}^{k_q} [j] = R_{U_i}^{k_q}, \text{ if } R_{U_i}^{k_q} \leq \frac{n}{2}; \quad q=2;$$

$$R_{A_{\max}}^{k_q} [j] = R_{A_i}^{k_q}, \text{ if } R_{A_i}^{k_q} > \frac{n}{2}; \quad q=3;$$

$$R_{U_{\max}}^{k_q} [j] = R_{U_i}^{k_q}, \text{ if } R_{U_i}^{k_q} > \frac{n}{2}; \quad q=4,$$

where $R_{A_i}^{k_q}$ is values of adaptation estimates (ordinate) of the i criteria of the q quadrant from the k position of evaluation, $i = \overline{1, n}$; $R_{A_{\min}}^{k_q} [j]$ is massif of ordinates of indicators with minimal ordinate values of the q quadrant from the k position of evaluation: SR is an object of management; M is a subject of management; C is state authority; $R_{U_i}^{k_q}$ is values of utility estimates (abscissa) of the i criteria of the q quadrant from the k position of evaluation; n is the number of analyzed criteria; $R_{U_{\min}}^{k_q} [j]$ is massif of abscissas of criteria with minimal value of abscissas of the q quadrant from the k position of evaluation $j = \overline{1, m}$; $R_{A_{\max}}^{k_q} [j]$ is massif of abscissas of criteria with maximal value of abscissas of the q quadrant from the k position of evaluation; $R_{U_{\max}}^{k_q} [j]$ is massif of abscissas of criteria with maximal value of abscissas of the q quadrant from the k position of evaluation; n is the number of analyzed criteria; j is an index of the massif element; m is the number of criteria of massifs of an appropriate quadrant.

Results. The approbation of the offered technique is carried out. The results of the evaluation of behavioral characteristics are shown in the Table 2.

To automate the calculation process, an information system for forming the strategy of the production system has been developed (Fig. 2). The software module processes the data entered by the user, builds tactics, taking into account the usefulness and adaptation of the behavioral characteristics of the production system and provides results (Fig. 3).

Thus, the following combination of behavioral characteristics of record, potential, risk and weak state of production activity is obtained

$$T_M = \{M_1^{SR}, M_8^M, M_8^C; M_3^{SR}, M_4^M, M_4^C; M_7^{SR}, M_7^M, M_7^C; M_5^{SR}, M_5^M, M_6^C\}.$$

From the company executive's point of view, the indicator of the production rhythmicity is a powerful characteristic; the industry authority and the state regulatory authority believe that the work of the production system is positively affected by the change in equipment suppliers.

According to the head of the company, the second quadrant includes the indicator of integrated use of resources, and according to the industry authority and the state regulatory authority – the quality of material resources. These behavioral characteristics can benefit the company, but the ability to adapt to environmental conditions in them is weak.

Expansion of cooperation is at risk state, which is agreed by experts at three levels. This means that this behavioral characteristic must be paid attention to and neutralized by record components.

The fourth quadrant “Weak state” from the company executive's and industry authority's points of view includes an indicator of the rate of consumption of material resources per a product's unit, and from the state regulatory authority point of view it includes the balanced operation of production capacities. It is possible to increase the level of these indicators by increasing quality of resources and their integrated use.

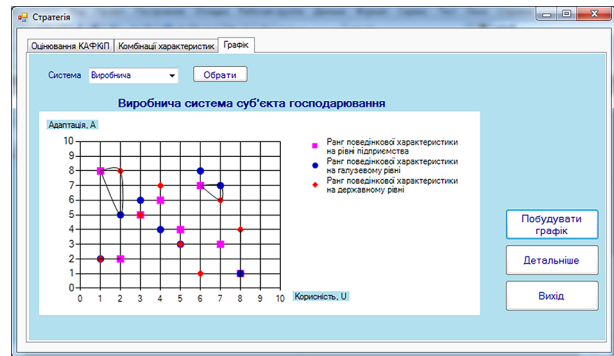


Fig. 2. Combinations of behavioral characteristics of enterprise production systems

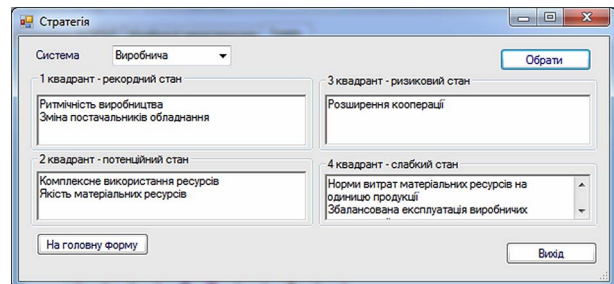


Fig. 3. Formation of the company's production system strategy

Table 2

Assessing the level of utility and adaptation of the production system indicators

Indicators	Identifier	Management object evaluation		Management subject evaluation		State regulatory authority evaluation	
		Utility estimate R_x^{SR}	Adaptation estimate R_y^{SR}	Utility estimate R_x^M	Adaptation estimate R_y^M	Utility estimate R_x^C	Adaptation estimate R_y^C
Production rhythmicity	M_1	0.82	0.74	0.63	0.72	0.67	0.53
Intensity of equipment operation	M_2	0.52	0.69	0.7	0.63	0.56	0.77
Integrated use of resource base	M_3	0.86	0.12	0.59	0.08	0.65	0.39
Quality of materials	M_4	0.78	0.53	0.89	0.57	0.75	0.38
Rate of consumptions of material resources per a product's unit	M_5	0.42	0.96	0.38	0.95	0.55	0.82
Balanced operation of production facilities	M_6	0.62	0.58	0.73	0.5	0.49	0.76
Expansion of cooperation	M_7	0.58	0.39	0.45	0.35	0.54	0.4
Changing of equipment suppliers	M_8	0.77	0.43	0.91	0.78	0.77	0.82

Conclusion. An approach is proposed that allows evaluating the production system of the mining and metallurgical enterprise, and differs from the existing ones in that it does not average the assessments of experts, but allows taking into account the opinion of each expert in determining future actions to implement the strategy.

An information system has been developed that allows forming a strategy based on the constructed combinations of tactics of the production system, taking into account the records, potentials, risks and weaknesses.

Based on the proposed approach it is also possible to carry out an estimation of other systems of activity and to form the complex strategy of a mining enterprise.

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Формування стратегії виробничої системи гірничо-металургійного підприємства за принципом тріади

Л. М. Савчук¹, Л. М. Бандоріна¹, К. О. Удачина¹,
В. С. Савчук², Р. В. Савчук¹

1 – Національна металургійна академія України, м. Дніпро, Україна, e-mail: eudachina7@gmail.com

2 – Національний технічний університет «Дніпровська політехніка», м. Дніпро, Україна

Мета. Формування стратегії гірничо-промислового підприємства з урахуванням конкурентних переваг виробничої системи з метою підвищення ефективності його функціонування.

Методика. Базою дослідження виступили: методи теоретичного узагальнення – при уточненні визначень: «поведінкова характеристика», «корисність», «адаптація»; експертний метод – при оцінюванні й ранжуванні вхідних параметрів системи визначення стратегії виробничої системи; сучасні інформаційні технології (середовище програмування MS Visual Studio) – при розробці програмного модуля.

Результати. Представлено алгоритм оцінювання корисності та адаптації виробничих показників за принципом тріади. Сформована стратегія виробничої системи на основі побудованих тактик за рахунок виявлення рекордних, потенційних, слабких і ризикових сторін поведінкових характеристик. Розроблено програмний модуль, що надає рекомендації за отриманими розрахунками.

Наукова новизна. Удосконалено методичний підхід до оцінювання параметрів виробничої системи гірничо-металургійного підприємства за принципом тріади, який, на відміну від існуючих, дозволяє враховувати три точки зору оцінювання: з позиції об'єкта управління (модель саморегуляції); з позиції галузевого органа (модель управління); з позиції органа державного регулювання (модель контролю), що дозволяє виявити конкурентні переваги за рахунок поведінкових характеристик виробничої системи.

Практична значимість. Запропонована модель оцінювання на основі тріади є універсальною й може бути використана у практичній роботі суб'єктів господарювання, що сприятиме підвищенню ефективності їх функціонування та забезпеченню цілеспрямованої діяльності, орієнтованої на прийняття обґрунтованих своєчасних рішень.

Ключові слова: стратегія, виробнича система, тріада, позиції оцінювання, адаптація, поведінкова характеристика

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