Analysis of the scientific and technical level of production and the introduction of innovation technologies in the ore-dressing plant

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Abstract. The process of obtaining iron ore at ore-dressing plant is a continuous process, so equipment failure at any stage leads to equipment downtime at all other stages. In this case, temporary shipment to the warehouse and from the warehouse of semi-finished raw materials leads to an increase in cost and a decrease in the quality of raw materials. These problems determined the purpose and objectives of the study of the possibilities of using a geographic information system to control moving objects in the main mine of the ore-dressing plant based on the system of automatic positioning using GPS or GPS/AVL (Automatic Vehicle Location). Based on satellite data, it is possible to generate various types of reports that allow to better control the situation - to analyze the qualitative and quantitative side of the ore mining process in quarries, to simulate the situation in order to avoid loss of working time. The basis of the study determined the economic effect of the introduction of GPS navigation in the main mine of the plant.

1 Introduction

The relevance of the introduction of new technologies lies in the fact that causes the transition of companies to a qualitatively advanced level of development and often becomes the determining factor of economic growth.

In world practice, quite a large experience has been gained in introducing innovative projects into industrial production. A large methodological base and no less extensive practical experience in introducing innovative technologies have been accumulated. The object of the research is the scientific and innovative activity of Evraz Kachkanar ore-dressing plant (Evraz KODP). The subject of research is the analysis of indicators of labor productivity and economic efficiency in connection with the introduction of innovations at the enterprise.

The main purpose of the study was to identify the main indicators of the modernization of fixed assets, aimed at increasing profits by reducing the cost of production units. Science,

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technology, and production - a single system developing in time, which is managed and planned as a whole. The norms of scientific and technical progress in production are the creation and introduction of new technology, progressive technology, qualitatively new products of labor, improvement of the organization of labor, production and management, aimed at ensuring the steady recovery of the country's economy and national welfare. There is a qualitatively new task of planning scientific and technological progress at the level of enterprises, associations and industries, ensuring its sustainable growth, as well as an integrated approach to the development of planning tasks for the scientific and technical development of production [1,2].

For the overwhelming majority of Russian enterprises, the introduction of innovations, both product and process, for several reasons is an urgent need, as well as ensuring the necessary and sufficient investment in the introduction of breakthrough technologies to create conditions for sustained multiple growth of social labor productivity and the fundamental training of innovative personnel of all categories, domestic breakthrough technologies that take into account the use of radically new physical and socio-economic principles of social reproduction; fundamentally prepared innovation personnel. The original idea of the ideology of innovative development is expressed in the qualitative improvement of all factors of production according to the levels of management and the flows of their organization. The final idea characterizes the repeated receipt of real positive results [3].

It is impossible to deny the fact that continuous improvement (in any form) is the life philosophy of any organization today, if it wants to survive and function successfully on average, not to mention a long-term period.

2 Methods

The basis of the system of methods for the universal determination of the measure of economic efficiency of the introduction of introduced new technology is better - comparing the costs of a new, what technology to translate from it effect.

To determine the economic potential - the effect obtained from the maximum number of units of new equipment under optimal conditions and the actual (possible) scale of implementation for individual years, count:

- reducing the cost of producing new equipment, equivalent in power to the old one.
- increase in output, which can be obtained due to the use of new technology.
- increase in profits from the manufacturer and the consumer due to the increase in production, cost reduction and price changes.

The following requirements are imposed on the scorecard [4]:

1. indicators should cover processes at all stages of the product life cycle.
2. indicators should be formed for the future (at least for 3-5 years) on the basis of a retrospective analysis of the organization's activities.
3. indicators should be based on data on the competitiveness of specific products in specific markets for a specific period.
4. the most important indicators should be expressed in absolute, relative and specific values (for example, profit, profitability of goods and production, the specific price of goods).
5. indicators should relate to all sections of the plan.
6. indicators should reflect all aspects of the financial activities of the organization (income, expenses, insurance, liquidity of securities and other assets, taxes, resource efficiency, etc.).
7. the design of the final indicators should be carried out on the basis of multivariate calculations, with the determination of the degree of risk and sustainability of financial activities, using sufficient and high-quality information describing the technical, organizational, environmental, economic and social aspects of the organization.

One of the main indicators of the effectiveness and stability of the organization is the indicator of its sustainability. It should be noted that the introduction of innovations can give four types of effect: economic; scientific and technical; social; ecological [5, 6].

3 Results

Evraz KODP Open Joint-Stock Company is located on the territory of the Kachkanar Municipality of the Sverdlovsk Region. Enterprise increases production of basic products every year. In 2018, proceeds from sales were received more by 13 227 million rubles than in 2017. The main share of revenue from product sales in 2018 was provided by: sinter and pellets 36 940 million rubles (97.9%) including:

- to the domestic market 33 966 million rubles (91.9%).
- for export 1 390 million rubles (3.8%).
- to CIS countries 1 583 million rubles (4.3%).

The share of sinter and pellets (in physical terms) shipped to the domestic market in 2017 was 90.6%, for export and to the CIS countries - 9.4%.

At all technological stages of JSC Evraz KODP, preliminary current and reverse control are carried out. The state and degree of progressiveness of technology largely determine the nature and results of production and determine the possibility of improving the technology. Analysis of the structure and age composition of fixed assets, their progressiveness and equipment of labor form the basis of the analysis of the organizational and technical level (table 1).

Table 1. Dynamics of indicators of the technical level of production of Evraz KODP for 2016-2018, %

Indicators	2016	2017	2018
The proportion of obsolete equipment	34,5	27,6	23,4
The proportion of modern equipment	14,8	26,3	29,4
The proportion of electronic equipment with automatic control	5,4	6,9	11,9
the proportion of progressive materials	13,6	17,8	19,7

As can be seen from the table, at the enterprise, the proportion of obsolete equipment is reduced, and the number of modern equipment increases significantly. In addition, for 2 years, the equipment with automatic control has increased in two times. The usage of modern materials is also growing.

The analysis shows a reduction in the total amount of capital investments of 387 million rubles, mainly due to the reduction in the volume of purchase of new equipment. During the period under review, four investment projects were implemented: “Modernization of the kiln machine No. 1”, “Modernization of separators”, “Installation of a commercial metering station for thermal energy”, “Automated system for commercial metering of electricity”. However, there is an increase in the cost of implementing investment projects and the development of information technology. Also, there is a significant increase in the repair fund - more than 9.5 times (table 2).

Table 2. Financing of the technical level of production of Evraz KODP for 2016-2018

The name of indicators	2016	2017	2018	change 2017 / 2016		change 2018 / 2017	
				+/-	%	+/-	%
Capital investments (mln rubles), incl.:	1 236,34	598,37	849,30	- 637,98	-51,6%	250,93	41,9%
purchase of equipment and other capital objects	924,64	347,26	417,81	- 577,38	-62,4%	70,54	20,3%
investment projects	292,80	222,86	330,29	- 69,95	-23,9%	107,43	48,2%
information technology development program	18,90	28,25	101,20	9,35	49,4%	72,96	258,3%
Repair fund, mln rubles	1 005,33	7 292,88	9 724,92	6 287,54	625,4%	2 432,05	33,3%

To date, over 300 employees actively involved in the development of the company offer about 50 rationalization proposals annually. The main objectives of innovation activities at Evraz KODP are:

- activation and further development of mass technical creativity of employees, as one of the most important conditions for the scientific, technical, and innovative development of the company.
- ensuring the legal protection of rationalization and inventive activity.
- increasing the interest of employees in the results of their work through moral and material incentives for technical creativity.

As a result of rationalization, the plant reduced water consumption from urban water bodies and reduced the discharge of process water by 32%. Reducing the burden on the environment has been achieved through the modernization of the technical water supply complex and the introduction of new environmental technologies. Currently, the plant has completely switched to a closed cycle of water supply: the water used in the process returns to production again.

The enterprise is actively introducing new more powerful equipment. The construction of new facilities and the launch of units necessarily envisages an environmental component.

In the crushing workshop the installation of two cascades of medium and fine crushing produced by the German company ThyssenKrupp is completed. The introduction of new technology at the plant significantly reduces downtime of production equipment, increasing production volumes and, as a result, labor productivity. To effectively reduce energy costs, it is necessary to continue developing energy saving programs. To continue measures to reduce the rates of consumption of raw materials and materials and to optimize the overall level of costs of the enterprise to reduce production costs.

According to the results of the work of the mine control unit, the equipment availability factor was 89%, which is lower than the target figure, which is 95%.

Consider the problem of poor performance of the availability of mining equipment. The process of obtaining iron ore at the mining and processing plant is a continuous process. Therefore, equipment failure at any stage leads to downtime at all other stages. Temporary shipment to the warehouse and from the warehouse of semi-finished raw materials leads to an increase in cost and reduce the quality of raw materials. The main task of the production workers of the main mine is to provide the technological process with ore raw materials.

The results of time-keeping observations of technological personnel conducted throughout 2018 showed that the average loss of working time due to organizational reasons for the locomotive crews of the central transit station was 69 minutes (9.6%) of the total shift duration (total shift time -12 hours (720 minutes), a part of this time loss (waiting for the route) is used as regulated breaks in accordance with the Ordinance "On the mode of work and rest of workers".

Figure 1 presents an analysis of the structure of the loss of working time by locomotive crews at the main mine of the plant.

Fig. 1. Analysis of loss of working time

As the analysis shows, there are significant losses of time within the framework of individual stages of the technological process, but the main share falls on waiting for the route and loading permission.

In this case, one of the ways to solve the problem may be to use the capabilities of the geo-information system, which allows you to optimize the routes of cargo delivery, considering various factors.

Geo-information automatic dispatching of transportation will reduce downtime of process equipment, save fuel and energy resources, increase productivity, and prevent accidents at work of Tseng [7] and work of Tseng Ventura [8].

The introduction of a system for automatically determining the coordinates of moving objects based on GPS or the GPS / AVL (Automatic Vehicle Location) system at the main mine of the plant will allow solving the tasks of dispatching the company's transport [9].

Each car is equipped with a GPS-receiver and radio communication equipment providing information transfer to the control center. On the monitor screen of the dispatcher using the GIS software, an electronic map of the territory is formed, which is served by vehicles [10]. Figure 2 presents the information obtained after the introduction of GPS - navigation in the main mine of the Kachkanar mining and processing plant.

Fig. 2. Display of the ore mining process on the main mine using GPS - navigation

Data on the coordinates and speeds of vehicles obtained over the radio channel allow to display their current position on this map. In addition to the coordinate information, signals from various sensors mounted on the vehicle and other information can be transmitted via a radio link. The location is shown on the computer screen, on the background of the map of the cuts and adjacent territories, on the mimicry of the track facilities, or in tabular form with an indication of the textual description of the location of each mining vehicle.

From the control room, the status of the sensors installed on each mobile unit is monitored: fuel, temperature, unauthorized opening of containers, turning the vehicle, turning on the flasher, etc. A special on-board computer operating in terminal mode can also be installed in the cab. In addition to text messages between the driver and the dispatcher, special forms (invoices, route sheets, etc.) are transmitted.

Automated control system of mining, mining-transport and transport equipment is designed for automated dispatching control of technological processes:

- excavation and loading operations of the excavator complex.
- transportation of rock mass (ore, overburden, clay, crushed stone) by rail.
- performance of shunting operations with auxiliary railway transport.
- performance of auxiliary operations for the maintenance of railways.
- transportation of rock mass (ore, stripping, clay, rubble) by heavy trucks.
- performing drilling operations.
- performing other operations with auxiliary automotive engineering and motor vehicles.

The next step should be the development of an automated data management system using geolocation, including:

- for an excavator complex - energy consumption metering, control of electric power quality parameters.
- for railway transport on electric traction - metering of electric power consumption, control of electric power quality parameters.
- for diesel rail transport - accounting for the amount and consumption of fuel, monitoring the parameters of the engine.
- for heavy trucks - accounting for the amount and consumption of fuel, monitoring engine performance parameters, monitoring tire operation.
- for electric drilling rigs - metering of electrical energy consumption, monitoring the parameters of electric power quality, monitoring compliance with the drilling regulations.
- for diesel drilling rigs - accounting for the amount and consumption of fuel, monitoring compliance with the rules of drilling.
- for auxiliary vehicles and bulldozers - accounting for the amount and consumption of fuel, monitoring the parameters of the engine, controlling the amount of fuel in the tank (for the tanker).

Based on the data obtained, it is possible to form various types of reports that will enable you to:

- control the situation.
- analyze the qualitative and quantitative side of the process of ore mining in quarries.
- to simulate the situation to avoid loss of working time.

Calculate the economic effect of the introduction of GPS - navigation in the main career of the plant.

Losses from non-produced iron ore raw materials due to unplanned downtime in 2018 were:

$316\,611.92 - 221\,783.31 = 94\,828.6$ thousand rubles.

The cost of introducing GPS navigation in the main mine is 56,000 thousand rubles.

$E = 94838.6 - 56000 = 38\,838.6$ thousand rubles.
The economic effect is obvious.

4 Conclusions

In the course of the study, the analysis of the scientific and technical level of production was carried out, as well as its influence on the indicators of efficiency and labor was studied. The work identified the key problems of development and improvement of the scientific and technical level of production, which made it possible to outline new directions for the innovative development of the enterprise.

It is quite obvious that an increase in labor productivity is possible through the use of advanced technologies, production automation, the use of specialization and cooperation of production units, the adoption of appropriate management decisions by managers and the rational organization of labor at the enterprise.

The recommendations proposed for implementation at the object under consideration have significantly improved the controllability of processes at the main mine of the mining and processing plant.

References

1. P. Richardson, A. Nigam, Creativity and Innovation Management, **4** (1999)
2. E.F. Levitas, M.A. Mc Fadyen, D. Loree, J. of Eng. and Tech. Management, **3** (2006)
3. J. Chen, C. Ren, F. Tao, WIT Transactions on Information and Communication Technologies, **46** (2013)
4. F. Adikara, B. Hendradjaya, B. Sitohang, Proceedings of International Conference on Data and Software Engineering, (ICODSE-2014)
5. V.G. Kuznetsov, T.N. Novikova, I.P. Kuznetsov, E.V. Kochetov, Gornyi J., **12** (2013)
6. T.V. Kochergina, M.S. Khokholush, T.I. Guseva, M.V. Selezneva, Revista inclusions, **7** (2020)
7. H. C. Tseng, P.P. Tu, Y.C. Lee, T. S. Wang, Inf. Tech. J., **12** (2013)
8. J. A. Ventura, S. Pazhani, A. Mendoza, Int. J. of Production Economics, **170** (2015)
9. S. Gilmore, D. Reijsbergen, Electronic Notes in Theoretical Computer Sci., **18** (2015)
10. I. Pivovarova, M. Tregubova, ARPN J. of Eng. and Appl. Sci., **2** (2018)