Journal of Engineering and Applied Sciences 12 (Special Issue 11): 9110-9113, 2017
ISSN: 1816-949X

Justification of Efficiency of Mining Enterprise Conversion

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Abstract: The study is devoted to the justification of efficiency of mining enterprise conversion to innovative technologies with the optimal combination of investment and production and economic factors. The results of the analysis on the cause of the ill-being of the mineral resource complex in Russia are given and the mechanism for creating the economic effect of mastering innovations is detailed. An assessment of the innovative development of mining companies by production functions is represented. Models for describing the experimental determination of economic efficiency of metal output increase as a result of mastering innovative technologies are proposed.

Key words: Conversion, mining enterprise, innovation, technology, investment, mineral resource complex, economic effect, metal

INTRODUCTION

The demand for non-ferrous metals has increased what requires the preparation of mining enterprises for new operation conditions. Mining companies are often unable to function effectively in market conditions due to depletion of deposits and with use of obsolete technologies and need reconstruction based on innovative technologies (Ermishina, 2011; Golik *et al*., 2007, 2015a-d, 2016a, d).

But, often being, in favorable climatic and mining-geological conditions and having a developed infrastructure they are suitable for further operation. The economic efficiency of an innovative technology is determined by commercial calculation, taking into account the useful properties of the production facility and its ability to make a profit.

The economic feasibility of conversion of a mining enterprise with the optimal combination of investment and production and economic factors is justified by the formalization of the Cobb-Douglas production function including capital indices, work-force size and industrial production volume (Golik *et al*., 2016; Khasheva and Golik, 2015; Muratovna *et al*., 2016; Komashchenko *et al*., 2016; Lyashenko *et al*., 2008; Logachev and Golik, 2009).

MATERIALS AND METHODS

Mechanism of innovative technology effectiveness justification include optimization of economic performance on the basis of economic and mathematical model describing the relationship of output, time, expenditures, recoverable value and risk of mastering the innovation. System “resources-innovations market” is optimized by the introduction of technologies adapted to the conditions of development of depleted resources, taking into account the development of the enterprise and the use of innovative technology model.

The main reason for the ill-being of Russian mineral resource complex is the use of the principle of extensive subsoil use with a significant deterioration in the quality of extracted raw materials. This is confirmed by the volumes of accumulation of secondary raw materials which is expedient to use bypassing the initial stages of extraction. Extraction and production of strategically important reserves of minerals: titanium, zirconium, lead and zinc, remained beyond Russia. Having possessed large developed reserves, Russia does not have sufficient capacities for their extraction and processing.

RESULTS AND DISCUSSION

The low power and length of ore bodies, low content of metals, depletion of most stocks and lack of possibilities for their development in comfortable conditions limit the possibilities of traditional methods of mining raw materials and cause conversion to alternative mining technologies. The conversion resource-saving and less capital-intensive methods of field development are being developed (Luzin and Golik, 2004; Shelkunova, 2005, 2006). The sharp decline in financing of the ore base facilities construction from state funds and the lack of own funds of the enterprises for this purpose led to a reduction in production over the period of 1995-2005 by

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45-50%. The model of industrial innovation development unites the scientific, technical and technological components of innovation development.

Sectoral innovation development manifests itself in the growth of the overall productivity in a specific type of activity and is associated with a change in the productivity of factors of production. Total productivity is understood as the productivity of all substituted factors of production. The scientific complex creates projects of innovation facilities with a new productivity. The engineering and technological complex is affected by two types of development: the engineering development and the development of technology by type of work increasing overall productivity. The engineering is a resource increase of materialized labor (fixed capital), which causes spending of other resources. The peculiarity is that the productivity of innovations, achieved in the technical complex, in the technological complex is not always manifested in full. The return from innovations is characterized by the contribution function.

The economic effect of innovation development is manifested in the growth of the overall productivity of production characterized by the rates of growth in metal production and the change in the structural relationships of the factors of production. When assessing innovative development, the base is the rate of metal production growth, productivity growth and increase in the life time of an enterprise.

The levels and the nature of manifestation of innovative development make it possible to assess the development of technology in a mining enterprise. The prerequisite for innovative development is the satisfaction of demand, the sufficiency of production opportunities to meet demand and profit taking.

The priority direction of the investment strategy is the technological re-equipment of mining enterprises, the decision of which is adopted on the basis of complex studies (Golik *et al*., 2015a-d; 2016a-d; Khasheva and Golik, 2015).

The period when non-recurring expenses are incurred and incomes are provided, takes a longer period of time than the investment project implementation period, what is manifested when new construction materials and technologies are implemented. When assessing the effectiveness of innovative technology, it is advisable to take into account not only the total mass of income for the entire useful life of the innovation but also its increase in comparison with the analogous technology. This means that with the technical and economic justification of innovative technology, one should begin with the theory of comparative effectiveness. Each cycle of investing in innovation reduces production costs and increases the volume of industrial depleted reserves. When optimizing the system parameters, a profit is generated:

$$\sum_{t=1}^{t_p} P_{p1t} = \sum_{t=1}^{t_{c1}} A_{bt}(Ts_{Dbt} - C_{Dbt})\frac{1}{(1+E)^{t_{c1}-1}} - \sum_{t=1}^{t_{c1}} K_r \frac{(1+E_K)^{t_{cr}}}{(1+E)^{t_{cr}-1}} + \frac{1}{(1+E)^{t_{cr}}} \sum_{t=1}^{t_p - t1} A_{rt}(Ts_{DGt} - C_{DGt}) \times \frac{1}{(1+E)^{t_p - t_c - 1}} + \sum_{t=1}^{t_p - t_{c1}} y_t \frac{1}{(1+E)^{t_p - t_{c1} - 1}}$$

Where:

A_{rt} = The production capacity of a mine in the t-th year (t/year)

t_{cr} = The period of preparation of reserves for leaching and construction of a solution processing shop (years)

K_r = Capital costs for preparation of reserves for leaching and construction of a solution processing shop in the t-th year (rub./year)

Ts_{Drt} and C_{Drt} = Recoverable value and operating costs when using leaching technology in the t-th year (rub./t)

E_k = The interest rate for a loan

y_t = The prevented environmental damage at liquidation of dumps and tailings in the t-th year

Mining projects are characterized by an increased level of risk associated with changes in mining and geological development conditions. Mining production has a significant capital intensity which is associated with the use of expensive equipment and the need for the greening of ore mining and processing technologies. The increased risk of mining enterprises is determined by the significant period of their construction which amounts to 5-8 or more years.

The risk assessment methodology has been tested in the course of substantiation of innovative technology for final development of the stocks in a particular deposit in the Republic of North Ossetia, Alania. For this, data on the geological and geochemical conditions of the deposit were systematized and possibilities for implementing the innovation scheme and the boundaries of the external and internal environment of the enterprise were explored.

To evaluate the innovative development of a mining enterprise, the production function method was used. An additional indicator (exogenous approach) was introduced and an innovation indicator (endogenous approach) was established.

As technical and technological re-equipment can become the main source of sustainable growth for mining enterprises, attention is paid to the patterns of exogenous technological progress as a growth factor. Based on the amount of the return on the use of factors of production, being the main element of technical progress, the return on the scale of growth should be estimated:

$$Y = F(K, L)$$

Where:
Y = Output
K = Capital
L = Labor input

$$\alpha = \alpha(K, L) = \alpha(K/L) = \alpha(k).y = Y/L = y(k)$$

The optimization problem is solved by constructing an equilibrium growth trajectory based on neoclassical models. Analysis of the production function makes it possible to determine the feasibility of the conversion of the enterprise to innovative technologies. The points (k_1; k_2) lie on the tangent curve f(k). If the inequalities $k_1<K/L<k_2$ are true, the optimal solution of the problem contains both capital intensities k_1 and k_2. The maximum economic growth of an enterprise is achieved if the "old" and "new" technologies coexist and must be transformed by reducing the share of "old" and increasing the share of "new" technological structures. The optimal solution is a combination of these two intensities k_1 and k_2 when the points $y(k_1)$ and $y(k_2)$ lie on one tangent to the curve y(k). The "new" and "old" coexist during the transition to innovative technologies.Increase in the rate of accumulation accelerates the growth of the enterprise. If s grows with time, then the share of old technology gradually decreases and at the end of the transition period the enterprise's economy comes to the point k_2. However, if the inflow of investment decreases, the process of technical re equipment of the enterprise also slows down and may return to the point k_1. Therefore, in order to transfer the enterprise to innovative technologies, it is important to ensure an inflow of capital sufficient to replace the old technology with a new one. To prove the effectiveness of the introduction of innovative technology, the Cobb-Douglas production function was used:

$$Q = a_0 F^{a_1} P^{a_2}$$

Where:
Q = The index of industrial production a_0-a_2 are the coefficients of elasticity
F = Fixed assets of the enterprise
P = Number of employees

The indexes of the enterprise for constructing the production function are shown in Table 1. The least squares method is used to calculate the elasticity coefficients (Table 2). The calculated value has good convergence with tabular value Q_t = 38.62. The economic effect from the introduction of innovative technologies is achieved with the coordination of technological solutions, what significantly improves the use of mineral reserves, accelerates the conversion of production and extends the life cycle of an enterprise (Table 3).

Table 1: Analysis of the exploitation of the archon field

Years	Extraction (thous. tons) (Q)	Funds (thous. rub.) (F)	No. of employees (P)
1999	34.7	21.792	40
2000	36.0	19.160	52
2001	35.2	20.970	48
2002	36.8	19.780	52
2003	40.2	20.340	67
2004	45.7	20.120	68
2005	48.3	26.520	62

Table 2: Production elasticity coefficients

a_0	a_1	a_2
0.01	0.616	0.528

Table 3: Technology indicators

Indicators/Unit of measurement	Technologies: Basic	Innovative
Subsoil use: dilution (%)	30	0
Losses (%)	20	10
Extraction of metals by mining (%)	100	200
Release concentrates: lead (tons/year)	7000	10500
Zinc (tons/year)	10000	15500
The price of concentrates: lead (rub./t)	555	555
Zinc (rub./t)	360	360
Cost: lead concentrates (thous. rub.)	3900	5800
Zinc concentrates (thous. rub.)	3600	5600
Annual metal production (thous. rub.)	7500	11400
Productivity for rock mass (t. m^3/year)	170	340
Volume of formed voids per year (thous. m^3)	220	220
Formed tails (thous. tons)	800	-
Additionally concentrates: lead	-	440
Zinc (tons/year)	-	680
The cost of concentrates as processed products (thous. rub.)	-	11400
Cost: building materials (thous. rub.)	-	200
Other metals (expert value) (thous. rub.)	-	400
Water treatment for boilers (thous. rub.)	-	200
Additional products (thous. rub.)	-	12200
Results of the technology use (thous. rub./year)	7500	19700
Saving on annual volume (thous. rub./year)	-	12200
Saving (%)	-	160

The results of the performed research may be claimed in determining the actual ways out of mining enterprises of a depressive type from a protracted crisis in market economy conditions (Golik *et al*., 2015). The provision of development conversion perspectives into underground one for Russian iron ore deposits development (Muratovna *et al*., 2016).

CONCLUSION

The economic feasibility of a mining enterprise conversion to innovative technologies is ensured with the optimal combination of alternative mining technologies. It is advisable to evaluate the economic efficiency of innovative technology implementation by formalizing the production function and analyzing its elasticity coefficients, taking into account the cyclical development of its economy and the capital intensity of the innovative technology. The mechanism of a comprehensive effectiveness assessment for the innovative technology at a mining enterprise includes the completeness and complexity of subsoil development, the use of existing infrastructure, the growth of commodity metal production and the reduction of production costs and the risks that affect the attractiveness of the innovation projects.

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