# TECHNO-ECONOMIC EFFICIENCY OF UTILIZATION OF MINING INDUSTRY WASTES FROM THE MURMANSK REGION IN THE BUILDING INDUSTRY

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***Key words: m***ining industry wastes, the building industry, efficiency, cost evaluation, strategy of wastes management.

The article discusses directions of utilization of mining industry wastes from the Murmansk region in the building industry. The Murmansk region is an industrially developed area and possesses a huge potential for production of local building materials.
There is proposed a number of measures to improve methodological basis for evaluation of efficiency of wastes utilization and economic stimulation of wastes processing. Specificity of economic evaluation of resources of multicomponent raw materials are considered and it is shown that the crucial condition of efficiency of separate extraction of every valuable component at comprehensive utilization of raw materisals is payback of direct costs.
It is proposed to elaborate a program for wastes management as one of the real efficient instruments for solving problems in this field.

There are considered several ways of utiluzation of mining waste from Murmansk region in the building industry, measures of improving methodological basis of assessment of the efficiency of waste management, economic incentives for its recycling. The condition of effective extraction each of the valuable components separately with the integrated use of raw materials is the recoupment of factor costs. It is proposed to elaborate a program for wastes management as one of the real efficient instruments for solving problems in this field.

The Murmansk region is an industrially developed area in Russian Federation, which possesses a huge potential for production of local building materials. The area provides the necessities of Russia in phosphate ores, iron-ore mining, copper and nickel, chromic raw materials, develops many non metalic mineral deposits. As a result in production of major region mining works - LTD "Apatit", "Olenegorsky LTD", "Kovdorsky LTD", "Kola Mining and Metallurgical Company (industrial complexes "Severonickel", "Pechenganikel"), as well as local power plants a large number of different wastes are being formed. According to the latest official figures for 2004, the number of such wastes, including stripping and heading breed, metallurgical slag production totaled 140.2 million tons - 98% of all types of waste production and consumption in the regione[1]. At the same time under utilization there are in average no more than 4% of the waste output per year. Now the total accumulation in the territory of the Murmansk region mining wastes exceed 6.5 billion tons.

The most promising area of the using technological materials is adaptation of its in the building industry in major consumer multiassembley wastes[2]. The building industry is represented in the region mainly as the production of crushed stone, sand and porous aggregates, wall materials (silica bricks and stones bituminous concrete), products of facing stone, mortar and concrete, reinforced concrete constructions and products. A high material capacity, a variety of structural types of buildings and structures require that the raw material for the production of building materials must be mass, cheap and flexible in technology, ie suitable for the products' manufacture with a wide range of properties.

In response to fundamental changes in country's economics in the last 15 years, the supplying the regions with non-metallic raw materials owing to the centralized supplies. However, more attention should be paid to the issue of replacing the natural resources in the waste industry. Using waste in the production of building materials is of great importance to the national economy, especially for our northern region experiencing an acute shortage of low-cost building materials. Raw materials from wastes is much cheaper then another ones

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produced in natural quarries. Consumption of fuel by using technology selected products reduced by 10-40% and unit investment - by 30-40% [3]. Many types of building materials have to deliver from remote regions of Russia, the average radius of the transportation of cement, for example, in Murmansk region is for about 1500 kilometers, while in the whole country, it is 565 km. The value of construction work remains high, approximately 40-60% higher than the centre of Russia. The increase of transportation tariffs entail higher prices for imported construction materials.

The shortage of building materials in connection with the development and prospects for the construction industry the region (the development of Arctic oil and gas bearing deposits, the construction of Kola-2 and several other major projects envisaged development strategies in the region)[4] requires finding new, more accessible and cheaper sources of raw materials. Big priorities have wastes of enterprises' mining complex: the stripping of rock, tailings, metallurgical slag and gold wastes of local Heat Stations.

The practice of stripping and incidentally harvested species in the manufacture of construction materials indicates the getting of a significant economic impact. In the region it has been already accumulated positive experience of the issuance of building stones from the rocks stripped iron deposits OAO "Olkon": It has been reached 17%-mounted recycling stripping rock produced 2 million m3 of commercial gravel per year.

OAO "Apatit" possesses of big opportunities. It steers more than 20 million m3 of stripping rock nepheline breeds in the dumps annually, along with the development of mining deposits Knibini nepheline-apatite ores. Thus, for 1 ton of concentrate produced incidentally produces about 2 m3 stripping (capacity) of rocks, stored in special dumps. The cost of extraction and storage of overburden, as well as laying tails up to 19.6% of the value of apatite concentrate.

In fact, for domestic consumption in OAO "Apatit" it is used approximately 7% stripped rock (the annual volume of their production): mostly for the repair of roads career, backing-up mines, backfilling mines. Calculations by the Institute of economic problems KSC have shown that it will be economically appropriate to expand the use of stripping rock of Knibini apatite-nepheline fields. Thus, the replacement of stones produced from natural material, gravel, produced from stripping the rock provides the economic impact up to 150 rubles. per 1 m3 of overburden (up to 240 rubles. / t) and 5.7 million rubles per year[5]. Opportunities for large-scale utilization of overburden in OAO "Apatit" in road building related to the implementation of federal target program "Modernization of transport system of Russia" (2002-2010) [6].

In the tailings dams of OAO "Apatit" hundreds of millions tons of wastes are accumulated, Mt: apatite - 45, nepheline - 460, sfen - 23 and titanomagnetit - 19. Each year, the tailings dams replenished at 18-20 million tons. Accumulated tails of apatite flotation can be widely used in the manufacture of ceramics, glazes, decorative glass, etc[7]. Granulated steel slag are being generated during the manufacturing process at the plant "Pechenganikel", along with the using the repairs of roads inside the quarry and laying mines is widely used as a small aggregate of concrete and obtain slag sement[8].

There are large reserves of raw materials for the production of building materials in thermal power. For example, the output of ash and slag mixture (ASH) at the Apatitskaya TPP is not less than 200 thousand rubles per year. ASH results of the study, performed in Kola Scientific Center, Russian Academy of Sciences, Apatity, Murmansk region[9] have shown the efficiency of their using as a mineral additive in heavy, light

| Enterprise, component | The limiting contents of components, % | | The minimal industrial contents, % | The average industrial contents in obtained ores, % |
|---|---|---|---|---|
| | by an offered technique | By other authors' technique | | |
| LTD "Apatit" | | | | |
| $P_2O_5$ | 2,1 | 9,0 | 9,5 | 13,8 |
| $Al_2O_3$ | 3,4 | 10,8 | 22,9 | 14,6 |
| LTD "Kovdorskii GOK" | | | | |
| Fe, gen. | 2,0 | 27,8 | 34,7 | 24,2 |
| $P_2O_5$ | 1,1 | 6,2 | 13,1 | 7,0 |
| $ZrO_2$ | 0,016 | 0,08 | 1,1 | 0,15 |

and AAC, while for using ASH the economy of slag sement depending on the type of concrete reaches 20%. It is possible to produce high-quality and cheap aerocrete products on the basis of these wastes: wall blocks, shell filters of insulation pipes, slabby heater.

The successful decision of tasks of complex utilization of raw materials and industrial wastes in building is a large reserve of increase of a production efficiency, an additional source of maintenance of construction by effective materials and designs.

As there is plenty of several kinds of waste and also various opportunities of their utilization, different degree of interchangeability with traditional products, points of accommodation of manufacture of the building materials received from wastes, the problem arises of optimization of using wastes a choice of sequence and directions of their recycling. The decision of such problems is possible by drawing up a statistical, a transport-industrial, a multistep and a multinomenclature model of objective utilization of mining waste in building branch. For this purpose it is necessary to define correctly the initial data for an estimation of economic efficiency, recycling of wastes, to define precisely and authentically their economic scopes in construction and the industries of building materials. The decision of this problem demands realization of actions in the field of perfection of a methodological basis of an estimation of efficiency of utilization wastes and provision of economic incentives of processing of wastes.

The process of extraction and processing mineral, as a rule, multicomponent raw material, is characterized by reception at different stages of manufacture of the big number of the multicomponent accompanying products which are subject to the further processing. In these conditions the differentiated definition individual, and especially public, estimations (the cost price, a capital intensity, power consumption, the price, etc.) separate components in initial raw material and received products extremely becomes complicated. On the basis of this estimations of rationality of the achieve level of complex use of the raw material, available reserves, economic efficiency of use of extraction of separate valuable components, an opportunity of recycling of waste are developed, and also economically objective variant of using raw materials is determined by strategy and tactics of development of the concrete enterprise, an industry, a mineral-raw complex of region prove as a whole.

The analysis of numerous inconsistent opinions of separate authors on methodological problems of economy of complex manufactures testifies to necessity of perfection of the conceptual device developed during the period administratively-planned economy on the basis of the departmental approach without a sufficient scientific substantiation. Ambiguity of definition and interpretation by different authors of essence and the maintenance of base concepts of complex use of mineral raw materials leads to ambiguous and inconsistent parcels, conclusions, methods of a quantitative estimation of level of efficiency and estimations of economic efficiency of extraction of each of valuable components of multicomponent raw materials, including expediency of recycling of a waste of different stages of manufacture. For the decision of the designated methodological problems it's necessary to make a research of features and use of raw materials from interdisciplinary positions on the basis of the system approach is necessary.

A well-founded cost estimation has a special value of an industrial waste and definition from positions of economy of basic possibility and economic efficiency of their recycling in building. The retrospective analysis shows that at the heart of occurrence, formation and development of complex utilization of mineral raw materials there was a processing of not used industrial waste. There are at least essentially various two directions of use of a mining waste: for recovery valuable components and building. In connection with exhaustion in the near future of not renewed resources of various kinds of mineral raw materials utilization of a wastes for recovery useful components is a priority. It's quite obvious conclusion that a large-scale use of a mining wastes in building is probably only in case of presence of the well-founded proof of economic inexpediency recovery valuable components from concrete kinds of a waste and in the foreseeable future follows now. According to this, the following approach to the decision of the designated problem is offered.

Boundary condition of efficiency of extraction each of valuable components separately at complex using materials is the

recoupment of a factor cost, directly and inevitably connected with the organisation of manufacture of each of them[10] that can be expressed a following parity:

$$\alpha_i \varepsilon_i Ц_i = (З_n + Р)_i, \quad (1)$$

where $\alpha_i$ - is the maintenance of i valuable component in initial complex of raw materials, unit shares; $\varepsilon_i$ - extraction of i valuable component from initial raw materials in a ready commodity output, unit share; $Ц_i$ - a marketing price 1 thousand of i valuable component in a commodity output, rubls.; $(З_n + Р)_i$ - a factor cost and resource payments ($Р$) - taxes to the extraction right, directly connected with manufacture i a valuable component, counting on 1 thousand initial raw materials, rubls.; i - a number of a valuable component, i = 1, 2, 3, ..., m.

With reference to the ore dressing enterprises a factor cost joins expenses on concentrating honing, control operations, a condensation, a filtration, drying, warehousing and concentrate storage, commercial expenses, including casing, cargo handling operations, transportation to a point of departure, loading in the car and other direct costs on a concrete concentrate.

From the first formula (1) quantitative sizes of the limiting maintenance of each of valuable components in initial raw materials are determined, the extraction of which is lower and, consequently, it is economically inexpedient to make the account in industrial stocks of complex deposits. The results of the calculation of the limiting maintenance of valuable components in ores of Murmansk region in comparison to their actual and industrial maintenance are resulted in the table.

Considering that resource taxes do not have extended on mining wastes, it is possible to define the limiting maintenance of valuable components $\alpha_{inp}$, below of which the corresponding wastes can be used in building without any restrictions:

$$\alpha_{inp} = \frac{З_n}{\varepsilon_i Ц_i}. \quad (2)$$

At the maintenance of some valuable components in a waste above corresponding their limiting maintenance an additional check of economic inexpediency recovery of valuable components from mining wastes is necessary. Such estimation should be executed according to conditions of excess of the predicted forthcoming total expenses connected with extraction of a waste from storehouse and with their complex processing, over total cost of valuable components taken from a waste at the account only that from them, which maintenance in an estimated waste above the limiting.

$$(З_к + \sum_i Зni) > \sum_i \alpha_i \varepsilon_i Ц_i, \quad (3)$$

where $З_к$ - is total indirect expenses for extraction and processing 1 t wastes. rubles; $\sum_i$ - summation over $i$.

In disarrangement of inequation (3) of using corresponding mining wastes in building is possible only after recovering from them valuable components, which maintenance above the limiting.

The analysis shows that in the process of development and perfection of technology of utilization a waste production received on their basis can pass different stages from substitute defective, but a cheap substitute of production received from other raw materials or on other technology, to a high qualitive and high-competitive production.

From the point of view of a cost estimation, irrevocable losses and unexploitable wastes are not subject to an estimation, as at the moment of formation they have no use value and, consequently, cannot have and an exchange value. From the point of view of the utility theory, "the useless thing for consumers has no price"[11].

However from the moment of the beginning of the industrial processing or realisation a waste passes to the party in a category used, fills up the nomenclature of the interfaced products of complex processing of mineral raw materials and should be estimated and be paid on the basis of these principles.

It is necessary to consider that the qualitative transition of mining wastes noted above from a category waste, not used in their formation, in a category potentially and then actually useful from the moment of working out effective technologists of their recycling (really having cost) in practice complicates and interferes with their productive use. The matter is that, on the one hand, the enterprises - the owners of wastes try to derive for themselves notable additional profit and try to sell them

more expensively, but on the other hand, any, even purely symbolical price psychologically pushes away consumers which might be possible yesterday. Besides, the cost estimation of wastes actually reduces and, at certain size, excludes possibility of reception of profit potential consumers.

The way out of this problem may be the following: first, in perfection and detailed elaboration of methodology of an estimation of economic efficiency in recycling mining wastes in a direction of fuller account and differentiation of all additional effects and expenses of the enterprises - the owners of wastes and their potential consumers, secondly, in perfection of methodology of a cost estimation of wastes and formations of the mutually acceptable price on a contractual basis. In particular, the estimation of economic efficiency of recycling of a waste should be carried out at zero cost of a waste, and their definitive contractual price will be defined from the coordinated distribution between participants of the general economic benefit of the concrete project of recycling of a waste.

Thus, on the basis of above mentioned words, one can notice that in the wastes of mining manufacture in Murmansk region the considerable quantity of valuable components is containing and there are real possibilities of utilization of wastes for manufacture of the building materials.

For the decision of the specified questions it is necessary to formulate the general strategy of a wastes management which should become a basis for working out of the regional resource-ecological program of recycling of industrial wastes. At this very moment such program is the real effective tool for the solution of problems, collected in the given sphere to draw attention of services of various levels (from local to federal). Each program should become a basis for acceptance of supervising decisions of an administration of the region, and also a source of the objective information for various services, organizations, persons concerned. The program should reflect the following: The analysis of the problem situation caused by accumulation of wastes, their regional inventory; definition of industrial and non industrial use, ways of neutralisation, an estimation of harmful influence on environment; revealing and studying of industrial deposits for the subsequent licensing; investment sources; monitoring of an ecological situation, an estimation of ecological risk.

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