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PERSPECTIVES FOR REPRODUCTION OF THE DIOXIDE TITANIUM INDUSTRY

Summary. Analysis of the mineral resource base of enterprises producing titanium products indicates that of titanium-magnesium, chemicals, lacquers, paints and other industries only to a small extent provided by the titanium raw material. Internal market capacity of titanium dioxide pigment is currently not particularly limited. A special place in the expansion and strengthening of the mineral resource base of titanium consuming industries of the country belongs to the North-West region of the Russian Federation. The proposed technology of the integrated use of titanium-magnetite ores is characterized primarily by its involvement on the basis of new, not previously used types of titaniferous raw materials. The use of technology allows to expand the range of recoverable mineral components and the range of products manufactured from a unit of feedstock. The technological scheme is a resource-saving way.

Keywords: resource saving, titanium dioxide, comprehensive utilization, deficit, marketing, development.

PERSPEKTYWY ROZWOJOWE W ZAKRESIE PRODUKCJI DWUTLENKU TYTANU

Streszczenie. Analiza bazy surowców mineralnych przedsiębiorstw produkujących wyroby tytanowe wykazuje, że branże tytanowo-magnezowa, chemiczna, lakiernicza, farbiarska i inne tylko w niewielkim stopniu używają tytanu jako surowca produkcyjnego. Obecnie możliwości zbytu pigmentu wytwarzanego z dwutlenku tytanu są zatem ograniczone. Szczególne miejsce dla ekspansji i umacniania bazy surowców mineralnych w branży wykorzystującej

tytan zajmuje północno-zachodni region Federacji Rosyjskiej. Zaproponowana technologia zintegrowanego wykorzystania rud tytanowo-magnetytowych jest charakterystyczna przede wszystkim ze względu na zastosowanie nowych, wcześniej nieużywanych, rodzajów surowców tytanowych. Wykorzystanie tej technologii pozwala na poszerzenie asortymentu odzyskiwalnych komponentów mineralnych oraz asortymentów produktów wytwarzanych z jednostki surowca produkcyjnego. Zaproponowany w artykule schemat technologiczny pozwala na oszczędność zużycia zasobów w procesie produkcyjnym.

Słowa kluczowe: oszczędność zasobów, dwutlenek tytanu, utylizacja, marketing, rozwój.

1. Introduction

Ensuring the economy of the Russian Federation in mineral resources of its own production after the collapse of the USSR as a whole decreased significantly, and some types of mineral raw materials became scarce. Analysis of the mineral resource base of enterprises producing of titanium products indicates that of titanium- magnesium, chemicals, paint and other industries only marginally provided with titanium dioxide pigment. Taking into account that in the long term the need of the country economy in titanium raw materials with economic growth will increase and taking into account the feasibility of non-import, it is necessary to harmonize the structure of the mineral resource base with the structure of titanium consuming complex of the country, by extending the scope of geological exploration, research and pilot tests.

The current lack of certain technical or technological solutions is a partial, local, temporary in nature and should not be a reason for not using resource-saving technologies. The final solution of the problem of recreation in Russia a reliable source of raw materials for the production of high-quality, competitive titanium products in quantities that ensure the internal market can be achieved by industrial development and integrated use of open primary deposits of titanomagnetite, perovskite and other titaniferous ores. The introduction of resource-saving technologies should be considered as one of the most important areas of investment in the mining industry.

2. Marketing analysis

In the developed capitalist countries in the field of production and consumption of titanium dioxide pigment in the average for 2000-2014 gg. there was a tendency to advance the pace of consumption growth (3-4,3%) over the rate of production growth in the paint

industry [9, 2, 23]. In the future, up to 2020 analysis of the dynamics of the pigment titanium dioxide consumption structure abroad by sector on major producing countries indicates that the vast majority of raw material will be consumed in the paint industry. Also, consumption of this industry expands considerably due to the substitution by titanium dioxide, of other pigments, in particular zinc and lead [3, 4, 24]. Titanium-containing raw material consumption structure represented by the paint industry (55-58%), pulp and paper (12.9%), manufacture of rubber and plastic (24%), printing inks (3%), as well as the production of ceramics, porcelain, glass, typographic paints 6% [3,5].

Table 1

Stocks (listed categories) titanium dioxide
and titanium concentrates production of leading countries

Country	Stocks, mln. tonnes TiO_2	Production, ths. tonnes	Share in world production, %
Canada	74,1	2500	20
South Africa	22,2	2250	18
Australia	45	1397	11
China	443,2	1350	11
Vietnam	4,5	1140	9
Russia	110	158	1

Source: State report on the status and use of mineral resources of the Russian Federation in 2013. The Ministry of Natural Resources and Ecology of the Russian Federation, Moscow 2014, https://www.mnr.gov.ru/upload/iblock/914/Report2014.pdf.

According to the USGS in 2013, the volume of the world's capacity to produce titanium dioxide was about 6.6 million tons / year, of which 71% came from China, USA, Germany, Great Britain and Japan. According to the company Ceresana is projected that by 2019 the capacity of titaniferous production raw materials, will reach 7.5 million tons per year. The largest producers of titanium dioxide are the company DuPont (USA) - 22%, Millenium (USA) - 13%, Tronox (USA) - 12%, Hunstman Tioxide (UK) - 10% and Kronos (Germany) to 10%. About 24% of titanium dioxide is produced in North America, 18.7% - in Western Europe, 5% - in Eastern Europe and the CIS, 35.2% - in Asia, 4.3% - in Australia, 1.2% - in South America, 0.5% - in Africa [17, 25].

The capacity of the internal titanium dioxide market is now almost unlimited. Even in conditions of considerable decline in the need of industrial production, the titanium dioxide pigment consumption is largely not satisfied, which leads to the necessity of its import and the import of paint products based on titanium dioxide. The large deficit in dioxide is already holding back more widespread its use in other industries. In the future, this situation is further

exacerbated if will not be found a solution that could fundamentally change the trend. After the collapse of the Soviet Union production capacity of titanium dioxide pigment were reduced by 80%, leaving only the Chelyabinsk paint factory with the capacity of 7 tons.

Currently, the proportion of the titanium dioxide in the structure of inorganic pigments remained approximately at the same level due to its import into the Russian Federation. Consumption of titanium dioxide in Russia is about 70-80 thousand tons per year (about 1.5% of the world total). Technology of production at the existing national enterprises provides the possibility of producing a very limited grade composition - no more than 3-4 grades. This vintage composition in any way does not satisfy the need of our industry, only 20% of white pigments match the level of the world standards [7]. Thus, the production of titanium in Russia is carried out only in passing, and on a small scale; the country's share in world production of titanium concentrates hardly exceeds 1% [Table 1][13].

It should be noted that due to the territorial changes that took place in 2014 when joining the Crimea to Russia, in our country [16], appeared another enterprise for the production of titanium dioxide CHAO "Crimean Titan" (Armyansk). This company operates on the basis of ilmenite concentrates coming from Dnepropetrovsk and Zhytomyr regions of Ukraine, and its share on the Russian market of titanium dioxide was about 30%. In 2013, the output of titanium-containing raw materials CHAO "Crimean Titan" was 107, 9 thousand. T., But the unstable situation in Ukraine and the change of the legal address of the enterprise to the address located in Kiev complicates at present time assessment of production prospects [26, 11, 1].

3. Analysis of the resource base of the Russian Federation

In the formation of mineral and raw material manufacturing base of titanium dioxide in Russia of all known and have industrial significance of titanium minerals used rutile, ilmenite, ilmenite-magnetite and loparite. After the collapse of the USSR the largest mastered by and prepared for the operation of the deposit containing rutile, ilmenite and ilmenite-magnetite ores, which are concentrated over 80% of titanium dioxide and for integrated use, which commercially exploited cost-effective technology, appeared outside the Russian Federation. Therefore, now faced the problem is essentially forming mineral and raw material manufacturing base of titanium pigment and recreating it, or rather re-creation based on the development of previously used non-traditional sources of titaniferous raw materials with the application of new technologies, which have not yet been tested in the national practice on an industrial scale.

Analysis of open, explored and exploited deposits of titanium-containing raw materials and the prospects for their integrated use for the production of titanium dioxide pigment

shows that traditional stocks titaniferous raw materials in the Russian Federation are very limited. Furthermore, their amount does not meet the required standards, which complicates the technology of processing and can not produce the necessary high quality grades of titanium dioxide [15].

Possibility to use for the production of titanium dioxide ilmenite concentrates of various chemical and mineralogical composition, as well as the opportunity to engage in the exploitation some new types of titaniferous raw materials (primarily titanomagnetite ores) occurs a result of the organization of concentrates production, which is a new type of raw material - titanium-slag is containing 70-80% titanium dioxide and no more than 10% iron oxides [22]. Completed in recent years, studies and pilot projects have shown that the use of titanium slag to produce titanium dioxide pigment has a number of significant advantages: It becomes possible to provide the industry with high quality raw materials with stable titanium-technological properties, which allows to obtain all the required titanium dioxide grades; It creates opportunity to engage in the processing of low-grade ilmenite concentrates with various oxidation states and different chemical composition; Opens ways to involve in economic circulation new types of titaniferous raw materials, in particular titanium-magnetite ores, with almost unlimited reserves; Greatly simplified technological scheme for producing titanium dioxide; It eliminates the problem of disposing of large amounts of iron sulphate that occur during processing. All this allows us to significantly expand the resource base of the titanium industry and practically organize the production of titanium dioxide pigment in amounts that satisfy the full requirements of national economy in the high-pigment titanium dioxide, of all required conditions. Also in this case, it is creates some opportunities for the environment protection.

Titaniferous raw materials having commercial value, represented by the North-West of the Russian Federation deposits titanomagnetite ores (Puduzhgorskoe in the Republic of Karelia, Kolvitsa in the Murmansk region.) Afrikandskimi deposits pervoskit ores (Murmansk Region.), Titaniferous magnetite and sphene concentrates, which can be obtained at enrichment of apatite-nepheline ore deposits of Khibiny group (Murmansk region.) ilmenite concentrate obtained in the beneficiation of ores loparite Karnasurtskogo deposit (Murmansk region) [20].

4. Prospects for the reproduction of the raw material base of titanium dioxide

In the North-West of Russia are open, but not explored, and other deposits of titanium magnetite ores, for example, Koykarskoe, Eletozero, Vuoriyarvinskoe in the Republic of Karelia, Gremyaka-Vyrmesskoe, Forest Barak, Tsaginskoe in the Murmansk region, as well

as the number of occurrences of the Ti raw material, which can be considered as Reserve mineral base of titanium raw materials. Explored reserves of various kinds of titanium-containing raw materials can be considered as a reliable source of raw materials for industrial complex for the extraction and processing of these raw materials.

To meet the future needs in the titanium dioxide is necessary the industrial development of located on the territory of the Russian Federation all the balance reserves of rutile, ilmenite, magnetite, titanium and zirconium ores. However, in this case the need is not to be covered by more than 30%. The deficit can be eliminated only through the development of dtitanium ore eposits in the beneficiation which is allocated in titanomagnetite, sphene, perovskite complex concentrates, and these concentrates processing with simultaneous extraction of all contained in it useful components. A large potential source of titanium raw materials are also apatite-nepheline ore at the enrichment of which, in the case of complex use, will be allocated titaniferous magnetite and sphene concentrate. Titaniferous raw materials of North-West Russia in the near future should be seen as objects of priority industrial development, as local supplies of titanium raw materials allow us to solve the problem of providing high-quality raw materials of titanium dioxide production.

The deposits of titanium ore in Northwest Russia are unique in quality and Ore Reserves, and are characterized by a high concentration in a relatively small area. It provides the basis for significant savings in the national economic costs due to the possibility of ensuring a high level of complexity of their use, a rational organization of production, and with the combination of territorial convergence of interrelated industries, and co-titanium complex industrial infrastructure line with companies in other industries. The creation of processing enterprises producing products with a high degree of readiness (pigmentary titanium dioxide, titanium calcite pigments, steel, ferrovanadium, etc.) contribute such factors as the identity of certain ores and concentrates on the mineralogical and chemical composition, the possibility of applying for processing modern resource technologies.

On the territory of the Russian Federation in the operation are located a number of deposits of complex ores, which can be considered as new sources of titaniferous raw materials, titanium dioxide, but which do not take into account the inventory balance. These include Khibinskaya field group of apatite-nepheline ores. Among the useful components of apatite-nepheline ore deposits of Khibiny group include titanium, embedded in the minerals - sphene and titanomagnetite. The technological scheme of enrichment of apatite-nepheline ore with the release of sphene and titaniferous magnetite concentrates developed and has passed a pilot production test. Total reserves of sphene, based on the average of its content in the ore (2.5%) account for at least 70-80 million tons, and the titanium dioxide in it 20-30 million tons Based on the balance sheet reserves in apatite-nepheline ores and medium content of titanomagnetite (1.2%) stocks titaniferous raw materials account for 60 million tonnes, and the titanium dioxide are at least 15-20 million tons. In general, stocks of titanium dioxide in the apatite-nepheline ores is 35-50 million tonnes [13]. Integrated use of such raw materials is

the most important economic and complex scientific-technical and economic challenges, especially in terms of their use as a raw material of titanium. Titanomagnetite and sphene are as follows according to the value and values of useful components following apatite and nepheline.

Scientific research and experimental-industrial testing of new technologies for complex processing of titanium ore was carried out for a long time [20]. To date, developed a technology for enrichment of apatite ore to produce apatite, nepheline, sphene, titanomagnetite and egerinovogo concentrates. In order to solve the problem of the use of titanium-magnetite and sphene concentrate as a titanium raw materials to the JSC "Apatit" in 1984 was set up experimental industrial plant "Pigment", is intended for the study of conditions in the semi-range of issues, starting with the separation of titaniferous magnetite and sphene apatite concentrates from tailings flotation and ending with obtaining from these concentrates the titanium dioxide pigment or finished products on its basis. By 1989, the plant has been fully mastered a titanium dioxide pigment of the anatase and rutile modifications obtained. The aim is - to bring the experimental industrial study to such a level to obtain the source data for the design and construction of industrial plants for complex processing of this type of titaniferous raw materials.

5. Conclusions

Justification of a rational sectoral structure of creation and development of the North-West of the Russian Federation of interbranch industrial complex is one of the most critical and complex issues of the regional economy. Substantial uncertainty, stochasticity of future economic development, as well as a lot of variation in the choice of the possible operation of the system trajectories require the use of more powerful and progressive economic decision-making apparatus - a systematic approach and optimal programming methods. Limiting the scope of use of flotation tailings of nepheline depends exclusively on the production program of apatite-nepheline concentrating factories to the current year of planning control, i.e., ultimately, it depends on the demand on the domestic and foreign markets in the apatite and nepheline concentrates. Construction as a part of JSC "Apatit" a pilot production for obtaining and processing of sphene concentrate, the ability to close scientific cooperation with ICTREMRM KSC, the developed technologies for production of titanium pigment and the feasibility of placing in the long term development of industrial production creates favorable conditions for the placement of a new on-site plant in Apatity town.

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Omówienie

Urzeczywistnienie racjonalnej struktury sektorowej w tworzeniu i rozwoju między-branżowego kompleksu północno-zachodniej Federacji Rosyjskiej jest jednym z najbardziej ważnych i złożonych problemów regionalnej gospodarki. Z powodu niepewności, stochastyczności przyszłego rozwoju gospodarczego oraz dużej zmienności kierunków, w których będzie podążał system, jest wymagane zastosowanie silniejszego i bardziej ekonomicznie progresywnego aparatu podejmowania decyzji, w tym także systematycznego podejścia i metod optymalnego programowania. Aktualnie obserwowany brak technicznych lub technologicznych rozwiązań nie powinien być jednak pretekstem do niewykorzystywania metod redukcji zużycia zasobów. W niniejszym artykule zaprezentowano bieżącą strukturę konsumpcji pigmentu wytwarzanego z dwutlenku tytanu w Federacji Rosyjskiej. Autorzy przeanalizowali również problem niedoboru jego produkcji na wymienionym obszarze. W zakończeniu sformułowano rekomendację dla stworzenia strategii odnowy bazy surowców mineralnych w branży tytanowej.