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Independence of Aluminum Industry on raw Materials as a Prerequisite of Sustainable Development of the Region

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Each industrial region should developed in balanced manner to meet the public demand for these or those forms of economic activities which is determined by factors and specifics of territorial differentiation of labor. Current state of aluminum industry in Siberia – one of the industries forming the backbone of industrial development of the territory – is specified by lack of stable, balanced operation between conversions and dependence on foreign markets of raw materials. The paper considers development specifics of aluminum industry in Siberia, proposes avenues of approach to solve one of the main problems of this industry – supply raw materials from "home" deposits, and shows additional development prospects for other industries brought about by multipurpose use of resources.

Keywords. Mineral raw materials, shortage, aluminum industry, balanced developed of region, integrated utilization, alumina, raw material base, by-products.

Introduction

Currently Siberia accounts for 80 % of primary aluminum produced in the country. The challenge for aluminum production in this region (as well as for Russia) is the shortage of raw material traditional for the global production – bauxites to produce alumina (crude product for production of aluminum). The need to purchase it abroad makes the aluminum industry resource-dependent and less competitive.

Earlier the authors studied opportunities to solve the raw material problem for existing capacities and for new designed alumina enterprises which is soon to become a obligatory prerequisite for the aluminum industry to develop in Russia. To reduce the transport component in production cost and taking into account availability of generating capacities in Siberia the authors suggest to give special priority to the mineral raw material complex of this region.[1]

Alumina production-based integrated utilization of raw materials to make various products can form the basis to develop other activities based on production of the currently scarce materials. This requires evaluating production output and by-products breakdown by sectors consumption.

Statement of the Problem

Various problems of non-ferrous metallurgy in Russia, such as: determination of competitive positions of different conversions of Russian

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aluminum industry in the global market, relations between enterprises of this industry and the state, showing opportunities to increase the raw-material independence were studied in the works by Arlyuk B.I., Akhmetov S.N., Bashlukov T.V., Zander Eu.V., Zlodeyev V.P., Kiselev V.V., Kozlovsky Ye.A., Rozin B.B, Rubinstein T., Sokolov V.M., Yagolnitzer M.A. and other works.

Results of above studies can be briefly summarized as follows. Currently the aluminum industry of Russia has changed from defense tactics to offense. Among the first steps was to create large integrated structures. However, as early as in 2007 large holdings turned from competitors into allies and merged into «Russian Aluminium» company. Shareholders of RUSAL own 66 % of shares of the United Company, 22 % – of SUAL, 12 % – of Glencor. To merge both Russian companies had good objective causes. To improve raw material self-sufficiency one of them – RUSAL – obtained raw material sources of more independent in this respect company – SUAL, the latter, in its turn, enjoyed all advantages of global scale business and financial assistance, strengthened its competitive standing in the integrated company. However, severe competition between global producers (aluminum conversion products) makes the companies assess their market position and continuously work to improve efficiency of their divisions at different levels and conversions. This, first of all concerns the mineral raw material self-sufficiency of the United Company and attainment of full independence from import. Besides, from the standpoint of raw material security to place stakes on import of necessary ores and non-ferrous metal concentrates is dangerous for Russia. Almost all of them are strategic materials and their import can be refused. This may happen not necessarily in aggravation of the international situation only. It is quite possible that import of raw materials into Russia can be blocked by Western transnational companies which have monopolized the hi-tech markets and develop their own metallurgical capacities in countries where the labor is cheaper than in Russia. As a result United Company «Russian Aluminium» has only a short respite in terms of raw material self-sufficiency, and it cannot be argued that the problem has been solved by the use of imported raw material only. As a matter of fact, for the export-oriented industry it is important and essential to have its own «raw material base». This was brought to attention in the works of such scientists as Akhmetov S.N., Dashkevich R.Ya., Zander Eu.V., Kiselev V.V., Kozlovsky Eu.A.

It is important that aluminum production in Siberia developed on the basis of generating capacities available here. This determined placement of aluminum smelters in this territory. Today Bratsk, Krasnoyarsk, Khakass, Sayanogorsk, Irkutsk, Novokuznetsk smelters consume the lion's share of electric power generated by local electric power plants. A full-scale energy complex cannot exist and function without sustainable operation of aluminum production and conversely. The latter along with the complementaries are part of the so-called system. The enterprises of the system evolve around utilization of the primary commodities and energy to form the «cycle». This is the definition made by I.G. Alexandrov in 1931. Later this term was methodologically and theoretically substantiated by N.N. Kolosovsky: «The energy production cycle (EPC) is understood to mean the entire totality of production processes successively evolving in an economic region on the basis of combining all kinds of finished products which can be produced in-situ, proceeding from moving the production to the sources of raw materials and energy and harmonious exploitation of all components of raw material and energy resources».[2]

Thus, another problem emerges – not only to evaluate feasibility of using local sources of raw materials to provide mineral raw materials for aluminum enterprises, but also to intelligently allocate produced wastes between by-product makers.

Authors of this study propose to use "home" – Siberian sources of mineral aluminum-containing raw materials to develop aluminum production and evaluate, at this, all "shots in the arm" of other enterprises and industries existing today with account of possible volume of sales of respective products. In this way the region can strengthen its self-sustenance to supply appropriate products for sectors of national economy and provide for sustainable development of Siberia.

Proposals

Among the weak points in actual status of aluminum industry in Siberia principal were lack of reliable raw material base in «extraction of mineral aluminum-containing raw material – production of alumina – electrolysis of aluminum» chain. Besides, this chain lacks a prerequisite for advanced development of industries and related enterprises – harmonious exploitation of all components.

Today the only enterprise producing alumina in the territory of Siberia – Achinsk Alumina Refinery (AAR) – is unable to meet the alumina demand even for the neighboring Krasnoyarsk Aluminium Smelter. AAR annual capacity is about 1 million tons of alumina, while to total demand of Siberian aluminium smelters is more than 5 million tons. Besides, depletion of the raw material base of this enterprise estimates the end of the life of currently exploited Kiya-Shaltyr deposit in 2020. Siberian smelters (or, rather the entire aluminum industry of Russia) suffer acute alumina shortage.

Development of alumina production in Siberia will relieve the tension in fuel-and-energy balance in the European regions of the country. Only one alumina refinery plant of medium capacity moved east can annually decrease the energy shortage in the European part of the country by approximately by 4 million tons of reference fuel and help save considerable capital investments and operation costs related to energy transfer from eastern areas.

To establish in Siberia a reliable resource base requires efficient use of local low-grade aluminum-containing raw materials: nepheline-containing rock, low-grade bauxites, disthene-sillimanite ores, high-alumina while boles. Chemical composition of these kinds of raw materials is given in Table 1.[3]

Theoretical foundations to jointly process the said ores for Siberian aluminum industry have been developed; their stock in Siberia in the areas in close vicinity of aluminium smelters is practically unlimited (Table 2).

Authors propose methods of defining ore mixtures most promising from the standpoint of high-priority development of respective deposits to open opportunities to plan placing alumina enterprises in the territory of Siberia. This will provide for steady operation of aluminum industry of the country.

In the authors' opinion to use domestic low-grade aluminum-containing raw material is not only to solve the raw material problem of aluminum industry but also to develop other sectors of national economy on its basis. The above said raw materials feature the following specifics: their processing into alumina is accompanied by production of great amount of wastes (8 tons of slurry – wastes – per 1 ton of produced alumina). Later this will inevitably have an adverse impact on the environment of the area. This requires complete integrated processing of mineral raw material, its planning must combine alumina production with account of its demand as raw material for aluminum conversion and

Table 1. Chemical composition of ores from different deposits

Raw material, deposit	Chemical composition of ore, %						
	K_2O	MgO	Fe_2O_3	Al_2O_3	CaO	SO_3	SiO_2
Nepheline ore (Kiya-Shaltyr)	2.9	1.3	4.4	26.5	8.1	0.31	40.1
Nepheline ore (Goryachegorskaya)	1.7	0.45	9.3	22.0	7.0	n/a	43.0
Kaolin clay (Kompanovskoye)	1.74	0.50	1.66	32.3	0.84	n/a	50.45
Disthene-sillimanite concentrate (Bazybaiskoye)	-	-	1.0	55.0	0.55	0.12	39.91
Bauxites (Iksinskoye, Plesetskoye)	0.44	0.26	6.9	52.5	0.6	0.64	17.8

Table 2. Composition of ore mixture minerals from different deposits

Composition of ore mixtures	Deposit, raw materials	Chemical composition of ore mixture, %						
		K_2O	MgO	Fe_2O_3	Al_2O_3	CaO	SO_3	SiO_2
0.7 Н + 0.3 Г	Nepheline ore (Kiya-Shaltyr) + Kaolin clay (Kompanovskoye)	2.552	1.060	3.578	28.24	5.920	0.210	43.19
0.85 Н + 0.15 DISTHENE-SILLIMANITE CONCENTRATE	Nepheline ore (Kiya-Shaltyr) + Disthene-sillimanite concentrate (Bazybaiskoye)	2.465	1.105	3.890	30.82	6.968	0.273	40.07
0.92 Н + 0.08 Б	Nepheline ore (Kiya-Shaltyr) + Bauxites (Iksinskoye, Plesetskoye)	2.734	1.235	4.600	28.58	7.500	0.327	38.31
Н	Nepheline ore (Kiya-Shaltyr) – base version	2.090	1.300	4.400	26.50	8.100	0.300	40.1

waste-free production, the latter should, at this, take into account demand of other enterprises for by-products.

Implementation of integrated processing of raw materials can decrease production costs of the prime product – alumina – reducing the prime cost of aluminum, too, and produce by-products at cost lower than by conventional production methods. E.g. assuming the industry-average cost of products given in Table 3, (produced by conventional methods) to be 100 %, with integrated processing of nepheline raw material their prime cost is given in Table 3. [4]

With slurry incompletely used for cement production the alumina production cost may be up to 99 % of the alumina prime cost by Bayer process. Production of alumina by bauxite sintering increases this figure to 139 %.

The diagram (Fig.1) shows principal lines of utilizing products made in integrated processing of nepheline raw materials. The biggest waste the processing of low-grade aluminum-containing raw material yields is cement (about 8 tons of cement per production of 1 ton of alumina).

It should be noted that the latter is a valuable construction material; to transport it for great distances (more than 700 km) is inexpedient because of the high transport component in the price of this product which later increases the prime cost of construction. Therefore it is necessary to evaluate possible volume of cement product sales in the territory of Siberia.

Table 3. Production cost of alumina refinery with integrated processing of nepheline raw material

Product	Industry-average production cost, %
Alumina	76
Soda ash	72
Cement	94

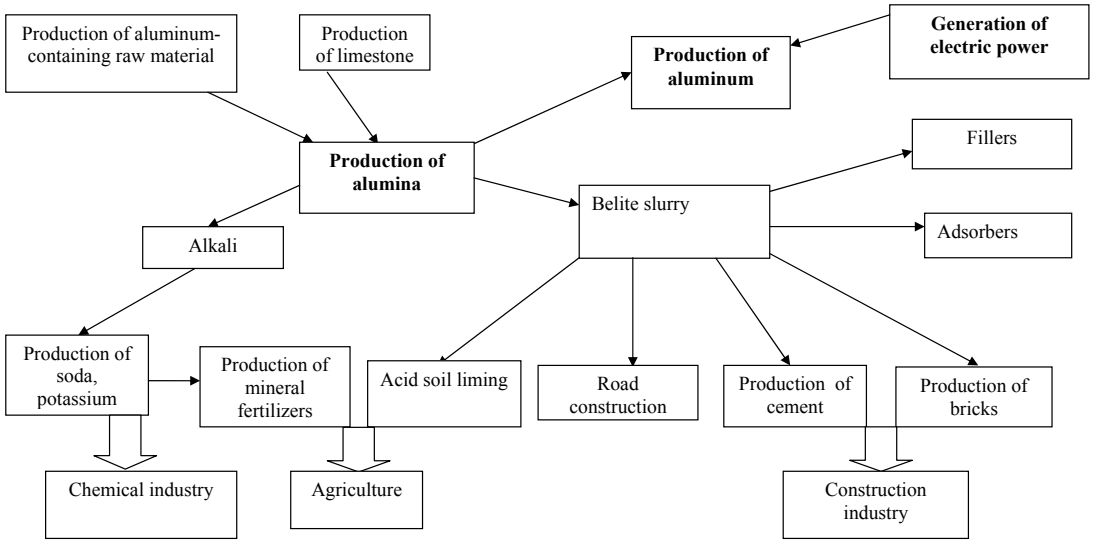

Fig. 1. Production of alumina in integrated processing from nepheline (low-grade aluminum-containing) raw material

Production of soda from nepheline is of great importance for the national economy, because it replaces its production of sodium chloride by ammonia process inflicting considerable environmental damage on the area. E.g. production of 1 ton of soda by conventional process produces about 10 m^3 of liquid chloride wastes with most adverse impact on environment. Production of soda from nepheline is practically waste-free. Besides, the «nepheline» soda is specified by elevated (2 – 2.5 times) bulk density which saves costs for packing, storage, transportation and improves its use efficiency.

Nepheline-based production of another product – potassium – can be most efficient. Considerable extension of potassium utilization is constrained by lack of this product. Very promising may be to use potassium both for the agriculture as a self-contained chlorine-free fertilizer and to produce new valuable forms of combined potassium-phosphorus fertilizers. The problem of potassium fertilizer is especially acute – without its own production the demand is satisfied by 10% only. Quite promising is also to use belite slurry to lime acid soil (25 % of all tillable land of the country).

Much attention should be paid to other applications of belite slurry. Among them are: production of calcium silicate bricks, wall components, nepheline-claydite concrete blocks, asbestos cement products and other autoclaved products, production of lightweight , heavy-

weight concrete, hydraulic concrete, preparation of construction and finishing mortars, production of filling mixtures, road construction.

These applications of belite slurry has been verified under production conditions (on standard equipment) and yield considerable economic effect.

Promising is the outlook of using slurry to produce belite refractories, ceramized glass, building ceramic and other materials.

Associated extraction of rubidium and cesium in addition to gallium can make processing of nepheline raw material economically more effective. The process of extracting the latter has been verified in pilot scale. Moreover, while gallium can be produced from other kinds of alumina-containing ores, associated extraction of rubidium and cesium is possible from the nepheline raw materials only. This production is substantially more economic than conventional production from rare metal raw materials.[5]

So, alumina production based on local deposits solves the problem of raw material supply for aluminum production and opens challenges to develop other production providing them cheaper raw material and, accordingly, improving competitiveness of their produce.

Conclusions

Aluminum industry of Russia concentrated mostly in Siberia suffers acute shortage of alumina – raw material for aluminum production. Alumina shortage, in its turn, is due to lack of our own raw material base – bauxites – which are mostly used as primary raw material for production of alumina all over the world.

To reduce the transport component in the prime cost of products, and taking into account availability of energy capacities in Siberia special attention should be paid to its mineral raw material complex, even more so that the deposits of aluminum-containing ore in this area at their time have been underwent serious tests for «usability» as raw material for alumina production by ore sintering with lime followed by hydrochemical processing of sinter.

To develop in Siberia reliable raw material base for aluminum industry local raw material should be efficiently used. Discovered reserves of low-grade aluminum-containing ores in Siberia are fairly large. Currently out of more than 100 deposits of aluminum-containing ores known in Siberia only one – Kiya-Shaltyr – has been industrially developed, and the end of its life for the combine has been estimated for 2020.

To make management decisions to overcome the raw material shortage the authors propose methods to evaluate and select various versions to use deposits of aluminum-containing raw material. The methods take into account many factors, such as complex composition of raw materials, multistage production processes comprising several interrelated conversions of raw materials and intermediate products, semi-finished products and main production wastes.

To develop the methods the authors intended to solve the problems of shortage of raw material (alumina) used for production of aluminum, this did not concern issues associated with necessity of integrated processing of nepheline raw materials and waste processing. In the meantime among distinctive features of nepheline raw materials is low content of aluminum oxide and at the same time elevated content of several other useful components which can be used not in the technological process only, but also for associated production of self-contained marketable products such as construction materials, soda products, mineral fertilizers, etc. Their production based on integrated processing of low-grade aluminum-containing raw material turns out to be more economic and the products – competitive. Lack of integrated processing increases prime

cost of alumina and makes necessary to solve environmental problems.

So, the shortage of raw material for alumina production can be resolved by the use of low-grade aluminum-containing raw materials from the deposits of Siberia. This involves the condition of its integrated processing to provide the opportunity to produce cheaper raw material (alumina) not for the aluminum production capacities only, but also to open prospects to develop other industries of national economy, primarily in the territory of Siberia. Taken on the whole this will make aluminum industry of Russia raw-material independent and strengthen the elements and relations in EPC chain to form the basis for balanced development of Siberia.

[1] Smirnova, Zander, 2011
[2] Kolosovsky, 1947
[3] Dashkevich, 2003
[4] Abramov, 1990
[5] Dantsig, Smorgunenko, 1982.

References

Zander Eu.V. Aluminum Industry of Russia: Competitive Development. Krasnoyarsk, 2005. – 142 p.

Dashkevich R.Ya. Alumina Production. Raw material bas of aluminum industry. Krasnoyarsk, 2003. – 68 p.

Zander Eu.V., Smirnova T.A. «Development of Raw Material Independence of Russian Aluminum Industry », *Regionalnaya economika:teoriya I praktika*, 6 (2008), 2 – 8.

Smirnova T.A., Zander Eu.V. Aluminum Industry of Russia. Ways to overcome raw material shortage, LAP LAMBERT, Germany, 2011. – 155 p.

Abramov V.Ya., Alexeev A.I., Badalyants Kh.A. Integrated Processing of Nepheline-Apatite Raw Materials. – M.: Metallurgiya, 1990. – 392 p.

Kolosovsky N.N. «Territorial Production Combination (complex) in Soviet Economic Geography», *Voprosy geographii, 6 (1947).*

Dantsig S.Ya., Andreeva Ye.D. Nepheline Rock – Integrated Use of Raw Materials. Moscow, 1982. – 192 p.

Сырьевая независимость алюминиевой промышленности как условие сбалансированного развития региона

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Каждый промышленный регион должен развиваться сбалансированно с непременным учетом потребностей общества в тех или иных формах хозяйственной деятельности, что обусловлено факторами и особенностями территориального разделения труда. Современное состояние алюминиевой промышленности Сибири – одной из отраслей, формирующих основу промышленного развития территории, – характеризуется отсутствием стабильной, сбалансированной работы между переделами и зависимостью от зарубежных рынков сырья. Авторами рассмотрены особенности развития алюминиевой промышленности Сибири, предложены пути решения одной из главных проблем этой отрасли – сырьевого обеспечения за счет использования сырья «собственных» месторождений, а также показаны возникающие при этом дополнительные перспективы развития для других отраслей при условии комплексного использования сырья.

Ключевые слова: минеральное сырье, дефицит, алюминиевая промышленность, сбалансированное развитие региона, комплексная переработка, глинозем, сырьевая база, попутная продукция.