Известия Уральского государственного горного университета. 2019. Вып. 2(54). С. 80-86

Технические науки
Engineering sciences

УДК 622.013.3:658.012.2(03)

https://doi.org/10.21440/2307-2091-2019-2-80-86

The main trends of development of the iron ore industry in Russia

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Introduction. Today, the Russian Federation leads the world in its proven reserves of iron ore, and ranks 5th in the world in production of marketable iron ore (enriched in iron). However, currently, there is an imbalance in location of metallurgical complexes and their raw material base that leads to negative economic consequences. At mining enterprises, the trend of permanent deterioration of the geological and mining technical conditions of the development of deposits is maintained. Thus, the trend analysis of iron ore extraction and availability of reserves of mining enterprises to estimate the level of production and consumption of iron ore is an important task in modern economic conditions.

Results. Based on the trend analysis for mining, production and consumption of iron ore in Russia for the period 1990–2016 taking into account the contribution of regions to the extraction of raw ore and the production of marketable products, the dynamics of a decrease in the yield of marketable ore was determined due to deterioration of the quality characteristics of raw iron ore. Some patterns and supply behavior of iron ore within the regions of Russia and in foreign countries were analyzed. The structure of iron ore supplies for export has been determined. The distances of iron ore transportation between the regions of Russia are specified. Evaluation and the projected growth of the iron ore industry for the coming years are given. It was shown that over the past 5–7 years, there has been a stabilization of the supply of iron ore raw materials to metallurgical enterprises and for export at the level of 101–107 million tons/year; the growth in raw ore production (up to 2–7% annually) is primarily due to reducing its quality and reducing the yield of marketable ore with existing technologies of beneficiation.

Conclusions. It was established that the supply of iron ore raw materials for export reaches 30% of the volume of its production in Russia and amounts to 20–30 million tons/year. Estimated performance of mining enterprises indicate a stable position of the industry in 2010–2016 and for the short-term; there is an increase in raw ore production, maintenance a high level of output of marketable ore, improvement financial performance, and a strong position in the markets to the product.

Keywords: iron ore, raw ore, ore mining and dressing plant, headings, steel pellets, supply structure, production ouput, raw materials supply.

Introduction

The extraction of raw iron ore and the production of iron ore raw materials (IORM) for iron and steel industry (headings, agglomerates, steel pellets, etc.) are concentrated in the North-Western, Central, Ural and Siberian federal districts of Russia. Iron ore reserves are unevenly distributed within regions: Central region ~ 59% of all-Russian balance reserves; respectively, the Urals ~ 15%; North-West region ~ 4%; the Siberian region has ~ 13% of balance reserves; other regions ~ 9% of balance reserves of ore [1, 2].

Mining enterprises of the Central Federal District that develop deposits of the Kursk Magnetic Anomaly provide more than half of the output of marketable ore for pelletization and agglomeration (56.6% in 2016) and a significant part of raw ore production (47.5%). In the North-West region, 20.7% of marketable ore was produced (with crude extraction at 22.8%), in the Urals – 15.3% of marketable ore (23.5% of raw ore), in the Siberian region – 8.3% of marketable ore (6.2% raw ore).

Results

The dynamics of raw ore mining and commodity production, as well as the production of iron in Russia is shown in Fig. 1.

The given data testify to the stabilization of the output of marketable ore in Russia at the level of 101–107 million tons/year. At the same time, there is a negative trend of a decrease in the yield of marketable products in the iron ore sub-sector due to the deterioration of the quality of the mined raw ore. Having existing beneficiation technologies for maintaining a stable production of marketable ore this leads to an increase in production outputs and, consequently, unit costs. Compared to 1990, an increase in raw ore production was ~ 13%, while marketable ore production fell by 1.2% (Fig. 2).

Iron ore is mined mainly with the help of open-cut mining (~ 93% of the total output) by ore mining and dressing plant (OMDPs), which are part of the world's leading metallurgical holdings, such as EvrazGroup, OAO Mechel, OAO Metalloinvest Holding Company, OAO Severstal, etc. Among these enterprises, there are 8 largest mining companies producing over 85% of Russia's iron ore. The Table shows the main indicators of production and being provided with technological equipment for open-cast mining within the group of the largest mining companies of Russia.

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Main indicators of production and technological equipment for opencast mining at the leading mining companies of Russia in 2015.
Основные показатели добычи и оснащенность технологическим оборудованием для ведения открытых горных работ на ведущих ГОКах России в 2015 г.

Ore mining and dressing plant	Production output, million tons		Number of equipment, units (average)				Average weighted distance of transportation, km	
	rock mass	including ores	rock drilling machines	navy excavators	dump trucks	locomo-tives	motor vehicles	railway transport
Mikhailovsky	123.6	49.8	16.1	73.6	56.8	81.2	2.3	14.6
Stoilensky	86.0	33.5	9.0	40.0	38.0	45.6	3.0	10.8
Lebedinsky	101.5	50.5	17.6	46.3	32.7	50.2	2.7	15.2
Kostomukshsky	141.7	34.7	20.0	44.0	55.3	18.0	3.1	14.3
Olenegorsky*	49.2	13.9(12.1)	10.0	18.0	26.8	9.0	2.7	11.6
Kovdorsky	28.8	19.6	7.7	14.0	58.0	0.0	3.8	0.0
Kachkanarsky	74.0	59.4	15.6	37.0	28.0	36.4	1.3	11.1
Korshunovsky	44.8	9.2	6.8	21.1	50.2	14.0	3.0	8.6
Total**	649.5	270.6(268.8)	102.8	294.0	345.9	254.4	2.7	10.8

*Ore mining: total (including open-pit mining);
**Ore production: total (including open-pit mining).

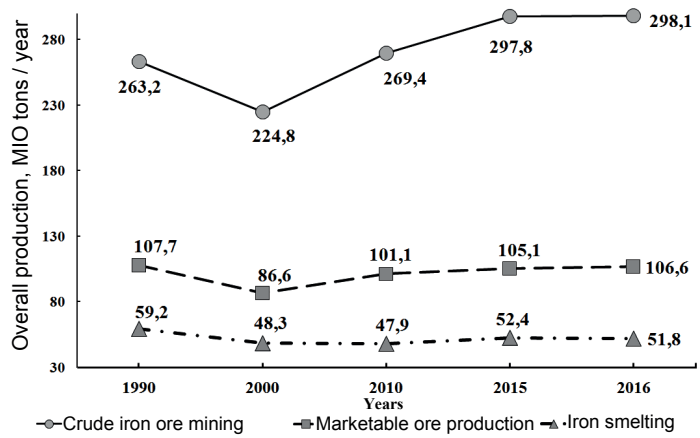

Figure 1. Dynamics of production of raw iron ore, production of marketable ore and iron smelting in Russia for the period 1990–2016.
Рисунок 1. Динамика добычи сырой железной руды, производства товарной руды и выплавки чугуна в России за период 1990–2016 гг.

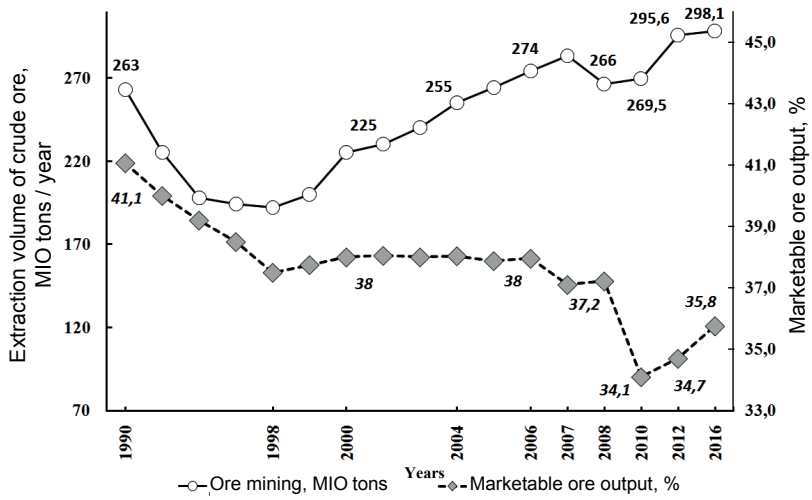

Figure 2. Dynamics of production of raw iron ore and the yield of marketable ore in percentage terms for the Russian Federation for the period 1990–2016.
Рисунок 2. Динамика добычи сырой железной руды и выхода товарной руды в процентах по Российской Федерации за период 1990–2016 гг.

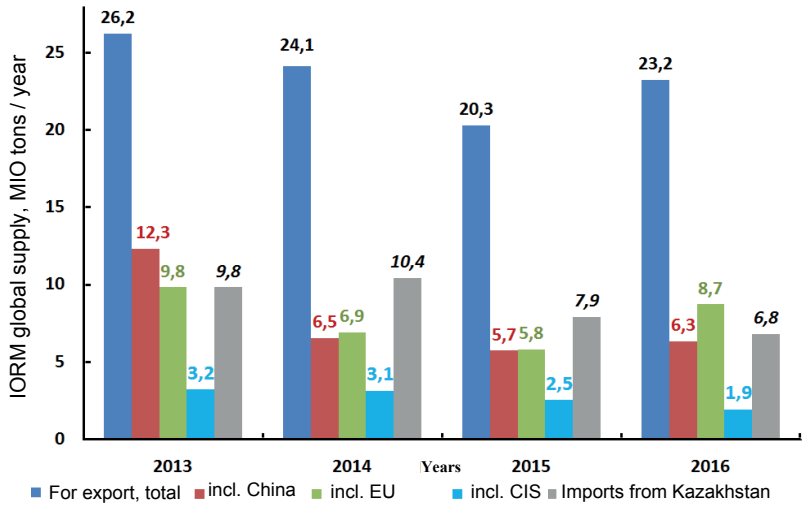

Figure 3. International supplies output of iron ore in 2013–2016.
Рисунок 3. Объемы международных поставок железорудного сырья в 2013–2016 гг.

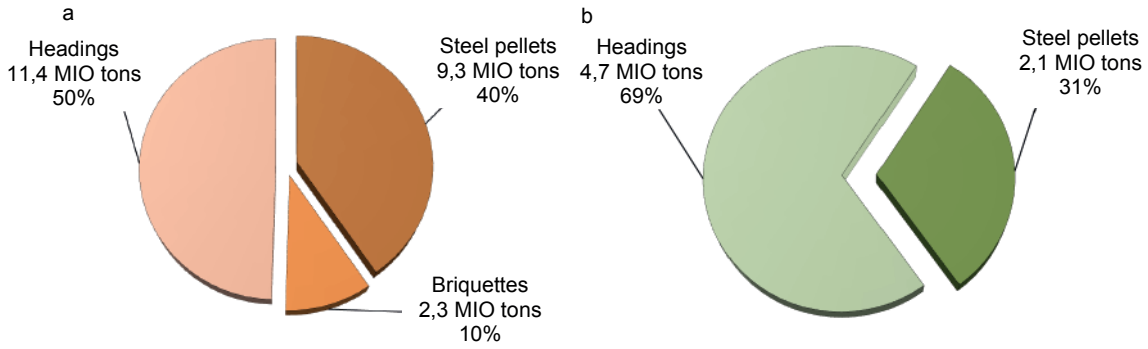

Figure 4. Structure of international supplies of iron ore in 2016. a – export, b – import (Kazakhstan).
Рисунок 4. Структура международных поставок железорудного сырья в 2016 г. а – экспорт, б – импорт (Казахстан).

For this group of enterprises, the capacity of a bucket of the average excavator is 9.4 m^3, the average loading capacity of the dump truck is 125.8 tons. In many respects, it is these enterprises that shape the future of the Russian mining industry in the field of open-cut mining and beneficiation of ore raw materials [3–7].

Sales geography of iron ore by ore mining and dressing plants is quite wide and covers both Russian consumers in all regions of Russia and foreign ones in the CIS countries, the European Union and Asia. Fig. 3 shows the dynamics of international export-import supplies of marketable iron ore in Russia for the period from 2013 to 2016.

Headings amount about 50% in supplies structure of iron ore for export, (Fig. 4), steel pellets are up to 40% and metallurgical briquettes are ~ 10%. The leader in exports and the only supplier of briquettes is Lebedinsky ore mining and dressing plant (8.2 million tons in 2016, more than 35% of the total output). Sales geography of iron ore to Lebedinsky ore mining and dressing plant is shown in Fig. 5 as an example of wide connections of industry leaders with consumers.

The given data show some growth in the supply of iron ore for export, which has reached a level of 20–26 million tons/year over the past years; it is up to 25% of the production of iron ore in Russia. The main consumers of iron ore from Russia are metallurgical enterprises of China, they account for up to 30% of the total output of exports; a significant amount of iron ore (6–10 million tons/year) is supplied to EU countries (mainly to Central and Eastern Europe); the CIS make export supplies to Ukraine in the amount of more than 2 million tons/year (1.7 million tons in 2016); Turkey (1–2 million tons/year), Japan (0.2– 1 million tons/year) and other countries are regular customers [8–13].

Import of iron ore to Russia is made only from Kazakhstan up to 10 million tons/year (6.8 million tons in 2016), which amounts to 10% of the production output of marketable ore in Russia. Deliveries from Kazakhstan go to the metallurgical enterprises of the Southern Urals.

Fig. 6 shows the scheme of iron ore supply between the regions of Russia.

The main volumes of produced iron ore are sold within the territory of its production (Fig. 6). Thus, in the Central Region, iron ore in the amount of 28.6 million tons/year is supplied mainly to Novolipetsk and Orsk-Khalilovsky metallurgical plants within 300 km. In the Ural region, the distance for transportation of steel pellets and agglomerates from Kachkanarsky ore mining and dressing plant (11.5 million tons) to Nizhny Tagil Iron and Steel Works slightly exceeds 100 km. Considerable distances for transportation of the main iron ore volumes within the region in the North-West are ~ 1.3 ths km; in Siberia – more than 1.8 ths km. The weighted average transportation distance of 1 ton of iron ore at Russia is ~ 670 km.

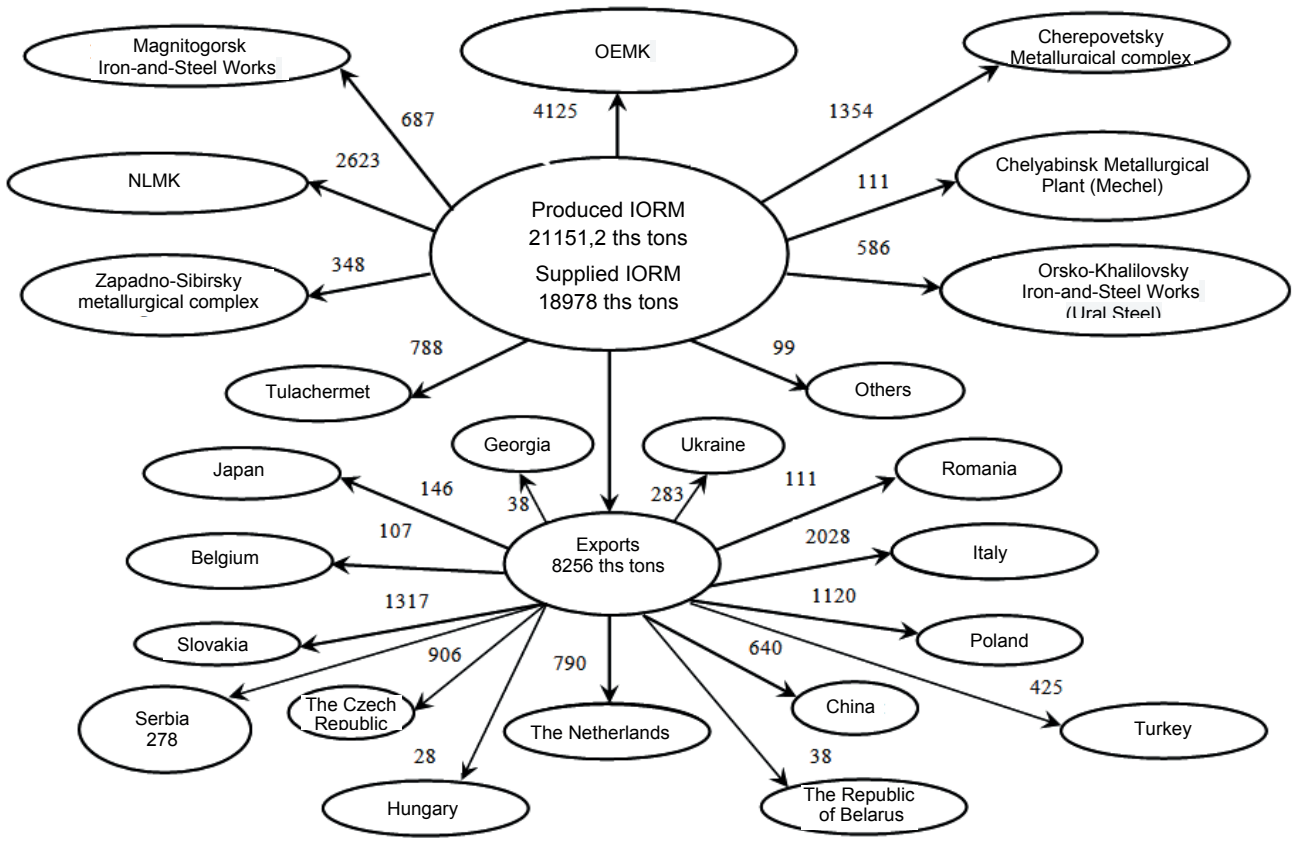

Figure 5. Production and supply of iron ore by Lebedinsky ore mining and dressing plant in 2016.
Рисунок 5. Производство и поставка железорудного сырья Лебединским ГОКом в 2016 г.

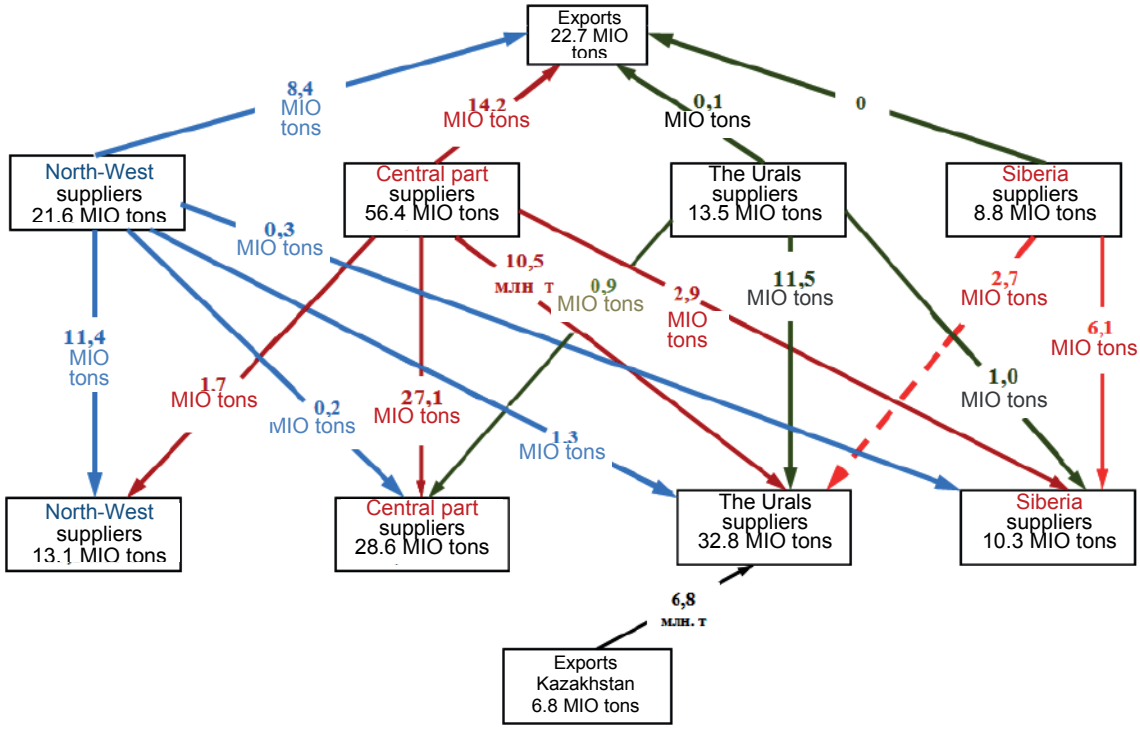

Figure 6. Iron ore supplies between the regions of Russia in 2016.
Рисунок 6. Поставки железорудного сырья между регионами России в 2016 г.

Conclusion

1. Over the past 5–7 years, there has been a stabilization of the amount of delivery of iron ore to metallurgical enterprises and for export at the level of 101–107 million tons/year. The production volumes of commercial ore in 2016 reached the level of 106.6 million tons (an increase of 1.5 million tons compared to 2015).

2. The growth in raw ore production (up to 2–7% annually) is primarily due to a decrease in its quality and a decrease in the yield of marketable ore using existing technologies of beneficiation. This negative trend is seen for a considerable time and leads to an increase in unit costs for the production of iron ore. In recent years, there has been a slight increase in the yield of marketable ore to 35.8% of the volume of produced raw materials by introducing innovative technologies for mining and processing.

3. The main production of iron ore is concentrated in the Central and North-West federal districts of Russia (~ 75% of the total Russian production). The remaining iron ore ~ 25% is produced in the Ural and Siberian Federal District. About 23% of Russia's crude iron ore with an average iron content of 15.7% is mined in the Urals region due to the development of the unique Gusevogorsky titanomagnetite deposit (Kachkanarsky ore mining and dressing plant), which is also the raw material base for extracting vanadium from smelter slags.

4. Iron ore is sold mainly within the region where it was produced. The distance for transportation from places of manufacture to consumers ranges from 100–300 km to 1.3–3.5 thousand km with a weighted average transportation distance of 1 ton of marketable ore in Russia ~ 670 km.

There is a rather high level of iron ore consumption by metallurgical enterprises in the Ural region – 32.8 million tons/year (up to 35% of the total demand), which are covered only 40% by production within the region.

5. Supplies of iron ore for export measure up 30% of the volume of its production in Russia and amount to 20–30 million tons/year. The main consumers of iron ore are Chinese metallurgical enterprises; they account for 7–12 million tons/year of raw materials (30–50% of export supplies), as well as EU countries consuming raw materials up to 10 million tons/year (up to 40% of export).

Imports of iron ore are produced from Kazakhstan in volumes of 6–10 million tons/year, which is up to 10% of Russian production. Iron ore from Kazakhstan is supplied to metallurgical enterprises of the Southern Urals that do not have their own raw material base, – OAO MMK plant (Magnitogorsk) in volumes up to 8 million tons/year and Chelyabinsk Metallurgical Plant – 2 million tons/year. In recent years, there has been a decrease in the supply of iron ore from Kazakhstan (a decrease of 1.1 million tons to the level of 2015 with Sokolov-Sarbai Mining Production Association) due to their replacement by supplies from the center of Russia (Lebedinsky and Mikhailovsky ore mining and dressing plants).

One of the options for replacing imports of iron ore is the development of new promising raw materials areas, including the Subpolar Urals, where the estimated resources of magnetite iron ore are estimated at level of 1.5–3 billion tons. Production of 8–10 million tons/year of iron ore in the Subpolar Urals can be carried out by open-pit mining to a depth of up to 250–300 m by a group of quarries with an ore productivity of 1–3 million tons/year with preliminary beneficiation in place by the method of dry magnetic separation and transportation of middlings to metallurgical enterprises of the Southern Urals[1] [1, 14].

6. Effective quality management of iron ore at ore mining and processing plants can be based on the following principles:

– continuous data validation on the quality characteristics of mineral resources based on the results of mining exploration, magnetic well logging, chemical analysis of raw materials at all stages of its processing, etc.;

– continuous data validation in GIS with updated data on mineral resources; use of GIS in mining planning (on annual, monthly, weekly, and daily basis);

– control the order of blasting of the drilled blocks of mineral resources; GPS positioning of excavation (the trajectory of a bucket and the position of an excavator in the mine face) and transportation navigation (taking into account the quality of raw materials in vehicles);

– implementation of automated control systems for the automated management of cargo flows in a quarry, taking into account the quality of raw materials;

– the use of pre-beneficiation in the quarry space on the basis of dry magnetic separation, and other innovations for cutting off substandard raw materials.

7. To smooth the negative impact on the efficiency of the iron ore industry, reserves reduction and deterioration the quality of iron ore in areas of traditional raw materials bases (especially in the Urals and Siberia), as well as to expand export opportunities, the organization of a new iron and steel industry in the east of the country is of great importance. The raw material basis for its creation can be deposits of easily beneficiated magnetite iron ores of the Aldansky iron-ore province of Yakutia with reserves approved by National Reserves Committee of the Federal Subsoil Management Agency: "Tarynnakhskoe" with reserves of categories B + C_1 - 1.1 billion tons, "Gorkitskoe" C_1 + C_2 - 1.9 billion tons, "Tayozhnoye" B + C_1 + C_2 - 1.25 billion tons, and deposits of high-quality metallurgical coal as well (Neryungrinskoe, Elginskoe).

8. In general, the performance indicators of mining enterprises indicate a stable position in the industry in 2010–2016. In the short term, there is an increase in raw ore production, maintenance a high level of the output of marketable ore, improvement financial performance having a strong position in the markets to the product. Also worthy of mention is the insufficiently active work on the modernization of fixed assets and increasing the productivity of mining equipment in quarries [5–16].

Acknowledments

This paper was prepared based on the survey conducted under the government contract No 007-00293-18-00. Topic No 0405-2018-0001. Project No 18-5-5-10. Justification of the methods and stages of adaptation of mining and technological systems to the changing conditions for the development of complex structural deep deposits.

[1]2000, *Metodicheskiye rekomendatsii pri otsenke effektivnosti investitsionnykh proyektov* [Guidelines for evaluating the effectiveness of investment projects] (second edition). Moscow, 422 p.

REFERENCES

1. Kantemirov V. D. 2014, Technological features of the development of new resource bases. *Gorny Informatsionno-Analiticheskiy Byulleten* [Mining Informational and Analytical Bulletin], no. 6, pp. 369–373. (*In Russ*.)
2. Kornilkov S. V., Kantemirov V. D. 2015, Iron ore deposits of Nether-Polar Urals as a promising resource base for the Urals metallurgy. *Izvestiya vuzov. Gornyy zhurnal* [News of the Higher Institutions. Mining Journal], no, 8, pp. 22–28. (*In Russ.*)
3. Shubina S. V. 2016, Economic and statistical analysis of the dynamics of mining in the Russian Federation for 2015–2016. *Ekonomika i predprinimatel'stvo* [Economy and entrepreneurship], no. 7 (72), pp. 886–890. (*In Russ.*)
4. Alikberov V. M., Tigunov L. P. 2018, Natural alloyed iron ores of Russia: state and prospects of use of the alloyed iron and steel in metallurgy, *Chernaya metallurgiya* [Ferrous metallurgy], no. 5 (1421), pp. 3–13. (*In Russ.*)
5. Yushina T. I., Petrov I. M., Avdeev G. I. et al. 2015, Prospect of using natural and man-made iron ore raw materials in the Russian Federation. *Gorny Informatsionno-Analiticheskiy Byulleten* [Mining Informational and Analytical Bulletin], no. 2, pp. 416–423. (*In Russ.*)
6. Yushina T. I., Petrov I. M., Avdeev G. I. et al. 2015, Analysis of the current state of mining and processing of iron ore and iron ore raw materials in the Russian Federation. *Gorniy Zhurnal* [Mining Journal], no. 1, pp. 41–47. (*In Russ*.) https://doi.org/10.17580/gzh.2015.01.08
7. Kabirov V. R., Reyshakhrit E. I. 2014, Effectiveness of an integrated approach to the development of metal ore deposits in groups. *Zapiski Leningradskogo gornogo instituta* [Proceedings of Leningrad mining institute], vol. 208, pp. 23–26. (*In Russ*.)
8. Meltzer M. L., Moroz O. N., Nityago I. V. 2017, Quantitative assessment of the level of clustering of the "extraction of mineral resources" industry in the regions. *Vestnik Belgorodskogo Universiteta kooperatsii, ekonomiki i prava* [Herald of the Belgorod University of Cooperation, Economics and Law], no. 6 (67), pp. 46–59. (*In Russ.*)
9. Dubihski J. 2013, Sustainable development of mining mineral resources. *Journal of Sustainable Mining*, vol. 12, no. 1, pp. 1–6.
10. Dadykin V. C. 2017, Analysis and forecast of mineral and raw materials for industrial enterprises of the central federal district. *Vestnik Severo-Vostochnogo federal'nogo universiteta imeni M. K. Ammosova* [Vestnik of North-Eastern Federal University], Series Economics. Sociology. Culturology, no. 4 (08), pp. 30–36. *(In Russ.*)
11. Yakubov N. M. 2014, Prospects for the global steel market. *Marketing v Rossii i za rubezhom* [Journal of Marketing in Russia and Abroad], no. 6, pp. 123–130. (*In Russ.*)
12. Dadykin V. S. 2017, Analysis and forecast of the main types of mineral resources of the Central Federal District according to the geological and economic monitoring. *Otkhody i resursy* [Russian Journal of Resources, Conservation and Recycling], vol. 4, no. 4. (*In Russ*.) 01RRO417. http://dx.doi.org/10.15862/01RRO417
13. Dadykin V. S. 2018, Analysis, modeling and forecast of optimal reserves for sustainable development of mining enterprises. *Nedropol'zovaniye XXI vek* [Natural resources management, XXI century], no. 2 (71), pp. 162–169. (*In Russ.*)
14. Mossakovsky Ya. V. 2015, *Ekonomika gornoy promyshlennosti* [Mining economics]. Moscow, 525 p.
15. Arkhipov G. I. 2017, Problems and priorities of the use of iron ore raw materials base of the Far Eastern region. *Gorniy Zhurnal* [Mining Journal], no. 3, pp. 15–19. (*In Russ*.) https://doi.org/10.17580/gzh.2017.03.03
16. Pluzhnikov I. F., Dunay E. I., Nemenyonok V. T. 2014, Contribution of the Belgorod iron ore expedition to the formation and development of the mineral and raw material base of the KMA Region. *Gorniy Zhurnal* [Mining Journal], no. 8, pp. 41–44. *(In Russ.*)

The article was received on November 29, 2018

УДК 622.013.3:658.012.2(03) https://doi.org/10.21440/2307-2091-2019-2-

Основные тенденции развития железорудной отрасли России

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Введение. Сегодня РФ по подтвержденным балансовым запасам железных руд является мировым лидером, а по объемам производства товарной железной руды (обогащенной и богатой по железу) занимает пятое место в мире. Однако в настоящее время имеется и в ближайшей перспективе сохраняется диспропорция в размещении металлургических комбинатов и их сырьевой базы, что приводит к негативным экономическим последствиям. На горнорудных предприятиях сохраняется тенденция постоянного ухудшения геологических и горнотехнических условий разработки месторождений. Таким образом, анализ динамики добычи железорудного сырья и обеспеченности запасами горнорудных предприятий для оценки уровня производства и объемов потребления железорудного сырья является важной задачей в современных экономических условиях.
Результаты. На основании анализа основных показателей добычи железной руды, производства и потребления железорудного сырья в России за период 1990–2016 гг., вклада регионов в добычу сырой руды и производство товарной продукции установлена динамика снижения выхода товарной руды вследствие ухудшения качественных характеристик добываемой сырой железной руды. Проанализированы схемы и динамика поставок железорудного сырья по регионам России и в зарубежные страны. Установлена структура поставок железорудного сырья на экспорт. Определены расстояния транспортирования железорудного сырья между регионами России. Даны оценка и прогноз развития железорудной отрасли на ближайшие годы. Показано, что на протяжении последних 5–7 лет отмечается стабилизация объемов поставок железорудного сырья на металлургические предприятия и на экспорт на уровне 101–107 млн т/год, а рост объемов добычи сырой руды (до 2–7 % ежегодно) в первую очередь обусловлен снижением ее качества и сокращением выхода товарной руды при существующих технологиях обогащения
Выводы. Установлено, что в настоящее время поставки железорудного сырья на экспорт достигают 30 % от объемов его производства в России и составляют 20–30 млн т/год. Оцененные показатели работы горнодобывающих предприятий свидетельствуют о стабильном положении отрасли в 2010–2016 гг. и на ближайшую перспективу, отмечается рост объемов добычи сырой руды, поддержание на высоком уровне объемов выпуска товарной руды, улучшение финансовых показателей, уверенное положение на рынках сбыта продукции.

Ключевые слова: железорудное сырье, сырая руда, горно-обогатительный комбинат, концентрат, окатыши, структура поставок, объемы добычи, поставки сырья.

Статья подготовлена по материалам исследований, выполненных в рамках Государственного задания 007-00293-18-00. Тема № 0405-2018-0001. Проект № 18-5-5-10. Обоснование методов и этапов адаптации горнотехнологических систем к изменяющимся условиям разработки сложноструктурных глубокозалегающих месторождений.

ЛИТЕРАТУРА

1. Кантемиров В. Д. Технологические особенности освоения новых сырьевых баз // ГИАБ. 2014. № 6. С. 369–373.
2. Корнилков С. В., Кантемиров В. Д. Железорудные месторождения Приполярного Урала как перспективная сырьевая база уральской металлургии // Изв. вузов. Горный журнал. 2015. № 8. С. 22–28.
3. Шубина С. В. Экономико-статистический анализ динамики добычи полезных ископаемых РФ за 2015–2016 гг. // Экономика и предпринимательство. 2016. № 7 (72). С. 886–890.
4. Аликберов В. М., Тигунов Л. П. Природно-легированные железные руды России: состояние и перспективы использования в металлургии легированных чугунов и сталей // Черная металлургия. 2018. № 5 (1421). С. 3–13.
5. Юшина Т. И., Петров И. М., Авдеев Г. И. и др. Перспектива использования природного и техногенного железорудного сырья в Российской Федерации // ГИАБ. 2015. № 2. С. 416–423.
6. Юшина Т. И., Петров И. М., Авдеев Г. И. и др. Анализ современного состояния добычи и переработки железных руд и железорудного сырья в Российской Федерации // Горный журнал. 2015. № 1. С. 41–47. https://doi.org/10.17580/gzh.2015.01.08
7. Кабиров В. Р., Рейшахрит Е. И. Эффективность комплексного подхода к разработке месторождений металлических руд в группах // Записки Горного института. 2014. Т. 208. С. 23–26.
8. Мельцер М. Л., Мороз О. Н., Нитяго И. В. Количественная оценка уровня кластеризации отрасли «добыча полезных ископаемых» в регионах // Вестник БУКЭП. 2017. № 6 (67). С. 46–59.
9. Dubihski J. Sustainable development of mining mineral resources // J. Sustain. Min. 2013. Vol. 12, № 1. P. 1–6.
10. Дадыкин В. С. Анализ и прогнозирование обеспеченности минерально-сырьевой продукцией промышленных предприятий Центрального федерального округа // Вестник СВФУ им. М. К. Аммосова. Сер. «Экономика. Социология. Культурология». 2017. № 4 (08). С. 30–36.
11. Якубов Н. М. Перспективы мирового рынка стали // Маркетинг в России и за рубежом. 2014. № 6. С. 123–130.
12. Дадыкин В. С. Анализ и прогнозирование основных видов минерально-сырьевых ресурсов Центрального федерального округа по данным геолого-экономического мониторинга // Отходы и ресурсы. 2017. Т. 4, № 4. 01RRO417. http://dx.doi.org/10.15862/01RRO417
13. Дадыкин В. С. Анализ, моделирование и прогноз оптимальных объемов запасов для устойчивого развития горнодобывающих предприятий // Недропользование XXI век. 2018. № 2 (71). С. 162–169.
14. Моссаковский Я. В. Экономика горной промышленности. М.: Горная книга, 2015. 525 с.
15. Архипов Г. И. Проблемы и приоритеты использования железорудной сырьевой базы Дальневосточного региона // Горный журнал. 2017. № 3. С. 15–19. https://doi.org/10.17580/gzh.2017.03.03
16. Плужников И. Ф., Дунай Е. И., Неменёнок В. Т. Вклад Белгородской железорудной экспедиции в формирование и развитие минерально-сырьевой базы региона КМА // Горный журнал. 2014. № 8. С. 41–44.

Статья поступила в редакцию 29 ноября 2018 г.

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