Development dynamics of the industry in Khakassia, technological solutions for a coal cluster

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Abstract. Today the coal industry of Khakassia takes the third place according to the index of industrial production, regarding extraction of coal, among regions of Siberia and the 14th place in Russia. Its further development is connected with creation of a coal cluster on the basis of enterprises producing and processing coal. There are all necessary modern capacities in the Republic. There are two coal processing plants, crushing and sorting complexes and also favorable conditions for developing transport networks connected to the perspective centers of coal mining in the country, capable to increase volumes of producing and processing coal, to increase quality of products. It is noted that the foundation of coal mining in Russia was laid at the end of the 17th century. The first deposits began to be mined near modern Donbass (area of the Kalmius river and the river Seversky Donets). The coal industry is one of major export developing industries of local economy.

1. Introduction
Russia is one of world leaders in production of coal. In its subsoil a third of world resources of coal and the fifth part of explored reserves – 193.3 billion t is concentrated. From them 101.2 billion t of brown coal, 85.3 billion t of coal (including 39.8 billion t of coked) and 6.8 billion t of anthracites. Industrial stocks of the operating enterprises make nearly 19 billion t, including the coked coals — about 4 billion t. The Russian Federation takes the second place on stocks and the fifth place on coal mining volume (more than 320 million t a year). Russia is in the third place in the world (after Australia and Indonesia) on world export of coal. Among the coal-mining Russian enterprises such companies as JSC SUEK, Kuzbassrazrezugol and “SDS-coal” are considered as the most outstanding. These companies head top three.

Now there are eight enterprises in the region that carry out activities for coal mining: LLC SUEK Khakassia, JSC the Steppe Coal Mine Coal company, LLC Vostochno-Betsyk razrez, LLC Arshanovsky Coal Mine, LLC UK Razrez Mayrykhsky, JSC Izykhsky Coal Mine, LLC Section Beloyarsky, LLC Vostsibugol-Khakassia (LLC KVSU-Khakassia) where more than 4.4 thousand people work. The main coal mining (85%) is the share of the Siberian Federal District where Western Siberia – 61.7% and Eastern Siberia – 23.9% of the all-Russian production are allocated [1].

In 2018 the largest manufacturing coal companies were: JSC SUEK (105.47), Kuzbassrazrezugol (44.5), “SDS-coal” (28.6), Vostsibugol (13.1), “the Southern Kuzbass” (9), Yuzhkuzbassugol (11.2), Yakutugol (9.9), JSC Raspadskaya (10.5), in brackets is specified amount of the produced coal in millions of tons, figure 1.
2. Khakass field, coal mining in the open way
Coal mining began in Khakassia 1904. It was organized mainly in Chernogorsk and Izykhsk fields. As a rule, Khakass coal fields have an important advantage that consists in the fact bedding of coal layers is absolutely near the land surface. Therefore coal is extracted only in open way. And it allows its prime cost to be practically the lowest in the country [2,3]. Process of coal mining is divided into overburden works and, actually, extraction of mineral. At first it is necessary to reach through dead and useless rock, coal layer. On the top layer, at the very beginning of quarrying by excavators, removing soil and not too dense rock. In process of deepening, the rock becomes stronger and the excavator without preliminary loosening cannot sort it any more. Further the rock is loosened in the explosive way. The loosening block is defined, then wells of the necessary depth are drilled, on all block the charge is put and explosion of mountain weight is made. Then it is necessary to remove all blown-up rock, to prepare next horizon. It will be again rock which will be blown up further, or already coal layer which will be mined.

3. Technology of coal enrichment, Stepnoy coal mine
The extracted coal is sent to consumers after processing at the factory where it is crushed and excessive rock is removed from coal [6,7]. The factory is located in several kilometers from Stepnoy coal mine and it was put into operation 5 years ago. The factory enriches brand coal D fractions of 0-300 mm (ordinary) with ash-content to 22.5% and the general moisture on a working basis up to 15%. As for the most technological process, it begins with coal crushing which happens on the crusher to a class of 0-200 mm. Further it is sorted, coal of a class of 0-13 mm and a class of 13-200 mm as a result turns out. At the following stage there is a so-called enrichment in the machine of BATAC. Further the received enriched concentrate is sorted on an inertial classification screen again. Then it is measured and analyzed in laboratories and shipped by cars. At factory the closed water and slurry scheme is used, i.e. technological water is not drained after use, and it is purified and supplied again to production. There are produced the following brands of coal:
- concentrate of the DPK brand having fraction of 50-200 mm with the ash-content of 8.1-9.1% and the general moisture on a working basis up to 15.6%, the lowest caloric content on a working basis – 5500 kcal/kg;
- concentrate of the DOM brand having fraction of 13-50 mm with the ash-content of 8.1-9.1% and the general moisture on a working basis up to 16%, the lowest caloric content on a working basis – 5500 kcal/kg;
• elimination of the DSSh brand having fraction of 0-13 mm with the ash-content of 19-21% and the general moisture on a working basis up to 15%, the lowest caloric content on a working basis – 4800-5000 kcal/kg.

Control over enrichment of coal throughout a technological chain, from a coalface to commodity coal, is carried out by specialists of checking department. The quality of high-quality coal meets great demands. It is placed by consumers as within the country, and in foreign market [8]. The enterprise has received the certificates of quality for all types of products confirming compliance of products to the international standards.

Since 2009 in the region the growth of industrial development has been observed, volumes of production grew twice from 10.1 to 21.1 million tons in 2017.

The most part of the coal extracted in 2017 in the region falls to the share of the enterprises of SUEK – over 13 million tons. Only for last five years growth of coal mining has been 23% that turned out to be consequence of technical modernization of cuts and concentrating factory “SUEK Khakassia”, JSC Razrez Stepnoy Coal Company is a participant of Russian Coal Holding, table 1.

| Name of the section/site    | Volume of production, one thousand t/g. | Share, % |
|-----------------------------|----------------------------------------|----------|
| Steppe section              | 4090                                   | 35.4     |
| Pereyaslovsky coal mine     | 4300                                   | 37.3     |
| Abakan coal mine            | 270                                    | 2.3      |
| Sayano-Partizansky coal mine| 600                                    | 5.2      |
| Erkovetsky coal mine        | 1080                                   | 9.4      |
| Northeast coal mine         | 1170                                   | 10.1     |
| Contact site                | 30                                     | 0.3      |
| In total                    | 11540                                  | 100      |

JSC UK Razrez Stepnoy is one of the leading enterprises bringing a coal mining share in total income of Russian Coal holding, figure 2.

![Figure 2](image-url)
As a rule, the Khakass fields have a considerable advantage that consists in the fact that bedding of coal layers is absolutely near the land surface. Therefore coal is extracted only in the open way. And it influences its prime cost that is practically the lowest in the country. Now development of the industry in the republic stimulates growth of economic activity in the region, including in the field of rendering transport and warehouse services, development of the railroads, construction of industrial facilities. One workplace in the sphere of extraction of coal creates up to two places in allied industries. Taking into account intensive development of the industry, by expert estimates of the coal-mining enterprises, the multiplicative effect concerning employment of the population gives in addition work to 12 thousand people in allied industries of production and services sectors. It will lead to growth of tax revenues in budgets. This circumstance is caused as a favorable environment of the world prices for coal, and conditions of open-pit mining of coal.

4. Dynamics of development of the coal industry in Khakassia

In 2014 the Arshanovsky coal mine was added to the working cuts. In 2015 Beloyarsky coal mine was started and in 2016 – Mayrykhsky coal mine. Today one more site of the Beysky field is offered for sale. And it means, this year one more cut will appear in Khakassia. The only problem which can prevent to carry out these plans is the low capacity of the Trans-Siberian Railway. However, the Government of Khakassia already took measures, according to the solution of this problem, in the next years together with the management of the Krasnoyarsk railroad and the coal enterprises of the republic the program for improvement of railway infrastructure is developed, at the Krasnoyarsk economic forum “KEF-2018” the Agreement is signed and the memorandum is carried out. The total amount of investments which in the next 5 years will go for development of the Southern course of the Trans-Siberian Railway will be nearly 30 billion rubles [9].

In the Republic of Khakassia the volume of extraction of steam coal during the period from 2000 to 2014 increased by 2.9 times and by the end of the period was 16 million tons, or 4.4% of the all-Russian volume of the extracted coal, figure 3.

![Figure 3. Dynamics of change of coal mining in the Republic of Khakassia from 2000 to 2014.](image)

From all volume extracted in 2014 the Khakass coal of 53.3% it is exported (3.8% to the level of 2013); 24.0% – for providing power plants (7.2% to the level of 2013); 11.4% – for needs of the population, domestic service and agrarian and industrial complex (– 11% to the level of 2013); 11.3% – for other consumers (1.0% to the level of 2013), figure 4.

In Khakassia the joint project of the Program of creation and development of the Beysky coal cluster till 2030 is developed. The project is developed jointly with specialists of East mining institute of design. The essence of the project consists in attraction of private investments into cluster infrastructure facilities, the state joint financing of construction of facilities of infrastructure,
placement of the power technological enterprises making a wide range of products of coal processing. Also, according to the project, the Beysky coal field of Khakassia should enter “The program of development of the coal industry of the Russian Federation until 2030”.

Presence at the coal-mining enterprises of Khakassia of modern capacities for production and processing of coal, the including two enrichment factories and crushing and sorting complexes and also the natural mastered conditions of production and availability of networks of transport communications allows to develop the region to the perspective centers of coal mining in the country, capable to increase volumes of production and processing of products, increasing its quality.

Intensive development of the Beysky field and further development of coal chemistry in the territory of Khakassia will allow to create a basis for deep processing of coal by creation of the central enrichment factory of ordinary coal, the plant on production of explosives, receiving liquid fuel, chemical products. Further development is provided in the direction of deep processing of coal, first of all in the organization of production divisions for enrichment of coal and processing of coal in semi-coke. In general in the Republic of Khakassia during the period till 2035 production of coal can increase by 2.2 times (the “maximum” option), due to development of production and processing of coal on republic cuts. Otherwise level of production of coal in the Republic of Khakassia by 2035 can remain at the level of 2014, figure 5.

![Figure 4. Supply of the Khakass coal in 2013 and 2014.](image)

![Figure 5. Development of coal mining got in Khakassia, during the period till 2035.](image)
5. Prospects of development of neogenic coal mines
Along with the prospects of development the coal industry faces also certain problems, there is big number of the shortcomings concerning ecological aspects of negative impact of the enterprises of the coal industry on the environment. So at coal mining there are known changes of landscapes; subsidence of the land surface, violation of soil cover, in this regard develop erosion; air pollution and waters; blowouts of methane as a result of coal mining; underground fires; ignitions in dumps. And also occupational diseases, occupational injuries.

First of all, acceptance of number of standards and laws which regulate development stages of fields can be the solution of the environmental problems connected with development of the coal industry. At the same time it is necessary to urge the coal enterprises of Khakassia to observe these laws at all development stages of coal layers. To prevent occupational injuries by improvement of means of prevention of ignition of methane and carbon dust. Development of systems of protection has to be based on creation of the explosion proof environment in mines. On developments methane oxidation reaction inhibitors have to be sprayed by oxygen. Gas-disperse safety environment has to be created continuously. Any dangerous factors of explosion should be reduced to safe limits. It is also necessary to provide ventilation of mines, to exclude possibility of electric discharges. For the solution of problems of occupational diseases of workers it is necessary to respect the rules, on any, to harmful factors which in Russia are accepted for a long time.

Today coal mines of SUEK are equipped with the modern equipment, appliances of the leading foreign and domestic manufacturers, the large-scale program for increase in safety of production is implemented. Efforts of the authorities in the region have created necessary conditions for implementation of long-term plans for creation of the world-class mining enterprises that for many years can become bearing part for region economy.

It is expected that the SUEK enterprises, in Khakassia in 2019 will receive record volume of more than 3.8 billion rubles.

The conducted researches as example, works of sectional view “Montenegro”, the mining enterprise at which development of layers is also carried out by open mode, equipment of the serving fleet of vehicles has been studied. Fleet of vehicles of sectional view consists of 52 large dump trucks. In addition, on mining operations 18 extraction cars, 2 boring cars, 11 bulldozers and 4 graders are involved. By results of time observations the mid-shift structure of working hours of team of mechanics on carrying out THAT BelAZ dump trucks, figures 6 and 7 is defined, communication between the volume of the executed operations, repair and the system of compensation is studied (figure 6, 7).

![Figure 6. Communication between specific costs of corrective maintenance and term of operation of dump trucks BelAZ 7530.](image-url)
From the Analysis of life cycle of dump trucks the BelAZ, proceeding from diagrams, it is possible to draw a conclusion that with increase in term of operation of BelAZ dump trucks specific expenses on THAT and repair grow, thanks to it it is necessary to reveal the most optimum terms of operation.

![Figure 7. Communication between specific costs of corrective maintenance and term of operation of dump trucks BelAZ 7513.](image)

6. Outputs
The Republic of Khakassia has the rich resource potential for industry development. The coal-mining industry and extraction of iron ore are the most developed in the territory of the Republic of Khakassia. The balance reserves of coals considered by the State balance of reserves of minerals of Russia in Chernogorsk, Izykhsky, Askizsky and Beysky fields make 8.7 billion tons. Balance reserves of coal of the Beysky field make 3.1 billion tons. In general in Khakassia during planning period from 2015 to 2025 coal mining should increase more than twice and make about 40.0 million tons per year, including on the Beysky coal field more than 22 million tons. The coal industry of the Republic of Khakassia is provided with explored reserves on perspective. In mountain withdrawal of the coal-mining enterprises about 10.1% of stocks of a total quantity are concluded. The coal-mining enterprises have a reliable source of raw materials and are provided with industrial stocks within the mountain branches for a period of 10 up to 120 years.

Internal consumption of the extracted coals in the Republic of Khakassia is about 1.5 million t. in a year. The main consumers of the Khakass coal are the housing and public utilities enterprises and the power companies. In spite of the fact that for export coal is shipped by only four coal-mining enterprises of the region: LLC SUEK Khakassia, JSC the Steppe Coal Mine Coal company, LLC Arshanovsky Coal Mine, LLC UK Razrez Mayrykhsky, shipment in the export direction exceeded 60% of all volume of production (about 13 million tons).

7. Conclusion
Thus, the coal-mining companies of the East Siberian region which includes the coal-mining enterprises of Khakassia are included into top three on coal mining that makes more than 80% of production of total amount about the country. And also we see, modern production of coal is quite large-scale, with a difficult technological chain and abundance of the various equipment Presence at the coal-mining enterprises of Khakassia of modern capacities for production and processing of coal, the including two enrichment factories and crushing and sorting complexes and also favorable conditions for production and availability of networks of transport communications allows to carry the region to the perspective centers of coal mining in the country with high modern technologies, a coal-mining cluster capable to increase volumes of production and processing of products, increasing its quality.
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