Formation of a commodity fuel portfolio of Kuzbass on the basis of coal preparation waste

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Abstract. The Kemerovo Region development strategy until 2035, updated in September 2020, is a forecast of the global technological leadership of Kuzbass, diversification of transport communications with other regions and states, adaptation to the conditions of the 2019 coal industry crisis. To solve these strategic tasks, coal mining and processing enterprises must balance their fuel portfolio and look for new ways to market their products, including the possibility of using production waste. Within the framework of the research carried out by the team of authors: the ecological, technological and economic advantages of using a coal-water suspension as a fuel component have been systematized; identified potential areas of its application; an analysis of the world experience of transporting coal through pipelines was carried out; a proposal was formulated for a project for the construction of the Kuzbass-Ural pipeline for the supply of coal-water fuel to Western Siberia and the Eastern Urals, and the advantages and disadvantages of coal hydrotransportation in comparison with its railroad delivery were identified.

1. Introduction

Russia is one of the leading coal mining and exporting countries, with 57 operating coal mines, 130 open-pit mines and 64 processing plants at the beginning of 2020. The total volume of processed coal products in 2019 amounted to 207.6 million tons (1.9% more than in 2018), including 205.9 million tons at the concentration plants (2.8% more than in 2018). Kuzbass is the most powerful coal supplier of coal mining regions, producing 57% of the total coal volume in the country.

One of the problems of industrial use of coal is the formation of waste from its processing. Process waters of mining and processing enterprises with small particles of coal are discharged into sedimentation tanks, hydraulic dumps, mined workings or into the nearest ravines and water bodies. In some cases, the sludge is dehydrated and placed on the territory of residence. At the same time, coal sludge is a highly toxic product, which contains flocculants and coagulants polluting the environment used at the processing plants [1]. The total volume of coal sludge produced by the Kuzbass concentrators is more than 10500 thousand tons per year.

The Kuzbass development strategy until 2035 sets ambitious goals for the growth of industrial production in general and coal production in particular, but a prerequisite for these trends is the strictest compliance with environmental requirements in the region. President of the Russian Federation V.V. Putin has set tasks for the regional authorities to ensure environmental safety. At the same time, the requirements for the leadership of the Kemerovo region separately indicate the need to solve the problems of the city of Novokuznetsk. Since 2019, Novokuznetsk has been implementing a comprehensive program to improve the environmental situation, the activities of which are aimed at reducing environmental pollution by industrial enterprises, heat power engineering, transport, as well
as modernizing the state observation network for air pollution and strengthening environmental supervision. By 2021 in Novokuznetsk, it is planned to reduce the volume of harmful emissions by 7%, and by 2024 - by 20%.

Modern ways of using coal products in the energy sector should not be archaic. New strategic approaches are needed to address these challenges, given the global industry crisis that began in 2019. New technologies are needed that would make it possible to use the advantages of coal and minimize the negative consequences of its use. One of the solutions to the above problems is the active use of coal-water fuel (a dispersed system consisting of finely ground coal, water and a plasticizer reagent) within the region and ensuring the possibility of its transportation beyond its borders.

2. Materials and methods
The empirical basis of the scientific research was the analysis of Russian and international experience in the use of products obtained from coal preparation waste-coal-water fuel. A comprehensive study of this issue was carried out based on a systematic approach. The methodological basis of the study was the scientific and educational literature given in the list of sources.

When setting the goal and defining the tasks of scientific research at the initial stage, the team of authors used an abstract-logical research method to study the possibilities and directions of using and transporting Russian coal through pipelines. The methods of comparative analysis and synthesis made it possible to identify, generalize and systematize the advantages of coal-water suspension in comparison with other types of fuel, as well as the advantages of coal-pipeline transport over railway.

3. Results
The analysis carried out in the work made it possible to systematize the environmental, technological and economic advantages of using a coal-water suspension as a fuel component (table 1), as well as to identify its potential applications (table 2).

| Type of benefits | Content |
|------------------|---------|
| 1. Environmental: | Safety for the environment at all stages of the operating cycle of use, reducing harmful emissions by 1.5-3.5 times. |
| 2. Technological: | Does not require modernization of structures of consumer enterprises; the operational processes of receiving, supplying and burning fuel are subject to mechanization and automation; resource utilization rate over 97%. |
| 3. Economic: | Saves the cost of fuel resources by 1.3-5 times; reduces storage, transportation and incineration costs by 15-30%; the investment payback period is 1-2.5 years; when incinerated, it produces material (fly ash) for use in construction. |

The widespread introduction of coal-water fuel can serve as the basis for the effective replacement of natural gas and oil at many thermal power plants and state district power plants with minimal capital costs and ensuring the required level of harmful emissions into the atmosphere.

In addition, due to the need to solve the problems of railroad congestion and the high cost of transportation, as well as the successful practical application of coal pipelines in the world economy, the team of authors considers it expedient to consider the construction project of the Kuzbass-Ural pipeline for the supply of coal-water fuel to Western Siberia and the Eastern Urals and conducting a factor analysis of its implementation. Such a coal pipeline can be laid through the regional centers of Western Siberia - Novosibirsk, Omsk, Tyumen, Yekaterinburg with branches to the north and south to ensure the supply of coal-water fuel to power plants and industrial enterprises in the south of Western Siberia and the east of the Urals. Further, construction can be continued to the western border of Russia to ensure the transport of liquid coal to Europe.
Table 2. Potential areas of application of coal-water fuel.

| Potential application of coal-water fuel | Benefits of using                                                                 |
|------------------------------------------|-----------------------------------------------------------------------------------|
| Fuel resource of boiler houses of housing and communal services. | Costs are optimized by 30-60% in comparison with the use of fuel oil and by 20-40% in comparison with coal combustion. Emissions of nitrogen oxides are reduced by 20-30%. Minimum investment for the reconstruction of boiler houses. |
| Heat and steam production in industrial plants. | Costs for steam generation of sugar, textile and other enterprises are reduced by 20-40%. Fast transformation of steam boilers to the use of VUT. |
| Additional marketable product for mine and open pit owners. | The use of own coal waste as liquid coal for production and technical needs allows to reduce the consumption of marketable coal products and get additional profit. |
| Fuels for asphalt plants. | Use in asphalt heating furnaces optimizes fuel costs. |

Coal pipelines, in comparison with railroad transport, have a number of advantages: uniformity and continuity of fuel flow; high reliability; high throughput of the system; averaging the quality characteristics of products; independence of transportation from weather conditions; no loss of minerals during transportation; reducing the negative impact on the environment; a small number of service personnel; high potential for automation of loading and unloading and transport operations; the possibility of using the earth's surface above them.

The main disadvantage of using coal pipelines is high capital construction costs, but if we compare these investments with investments in the construction of a railway, they are clearly less.

4. Discussion

Potential consumers of coal-water fuel are industrial organizations of various fields of activity and housing and communal services enterprises. Coal-water fuel can be the main or reserve fuel resource of boiler houses, as well as thermal power plants of various sizes. This fuel may be of particular interest for residents of new micro-districts, cottage settlements, and remote from energy resources.

Studies on the use of ash from thermal power plants as components of building materials and its application to obtain a hardening fill for filling mine workings and leveling the earth's surface [2-5] have shown high efficiency indicators, which can also reduce the volume of waste entering the sludge storage.

Currently, 99% of Kuznetsk coal is transported by rail; while the main drawback of transportation is the geographical location of the region (the average distance to seaports within Russia is 5075 km., to border crossings - 4093 km.).

In connection with the large volumes of transported coal, the issue of the throughput of railways becomes urgent, which is far from always sufficient to ensure rhythmic supplies of coal products. Since the Trans-Siberian Railway is overloaded, traffic jams are constantly formed at the exits from the Kemerovo Region.

In addition, since the early 1990s, there is an outstripping growth of transport tariffs in comparison with the prices for transported products: for the period, 1991-2009 wholesale prices for industrial products increased 34 thousand times, while railway freight rates increased 53 thousand times [6]. Today, transport costs account for up to 60% of the price of Kuznetsk coal, which, when delivered to ports, more than doubles the cost. The growth of railway tariffs negates the competitive advantages of the Kuznetsk Basin (quality characteristics of products, volumes of mineral reserves in the subsoil, the level of demand from consumers).

In recent years, cooperation between mining companies and the railway has been complicated by the constant settlement of issues in the areas of tariff determination, infrastructure development, and coordination of production and transport processes, which in modern conditions has led to the fact that
the coal top management sees the main risks of business and industry development in the transport component generally.

The solution to the accumulated production and transport problems can be the implementation of large investment projects by the railway to increase the throughput of its highways, accompanied by a decrease in freight tariffs, or the search for alternative ways of transporting coal.

Kuzbass coking coals and coke are in demand westward from the Kemerovo region due to the location of consumers. All metallurgical plants in the country have a demand for the products of the region, while the enterprises of the Eastern Urals consider our producers as the only suppliers of coal.

Thermal coal is also transported eastward, but most of it is also exported westward on the domestic Russian market. The main consumer organizations in the western regions include the Novosibirsk thermal power plants, the Tomsk power plant, the Barnaul thermal power plants, the Biysk thermal power plant, as well as local boiler houses. In addition, Kuznetsk coal is used for energy purposes in the regions of Central Russia, the Volga region, the Central Black Earth Region, and the Urals.

In the eastern direction, the consumers of Kuznetsk thermal coals are enterprises of the Far East. Kuznetsk coal is not used in the energy sector of Eastern Siberia due to the presence of large hydroelectric power plants, Kansk-Achinsk and other coal basins on its territory.

On the world stage, among the countries - importers of Kuznetsk coal and coke, there are more than 50. The volume of export of thermal coal exceeds that of coking coal. Regarding the location of the Kemerovo region, ¾ export volumes are carried out in the western direction. The main importers of energy grades are Great Britain, Finland, Romania, Poland, coking coal – Germany, Spain, Belgium, Slovakia, Hungary, Kazakhstan, Turkey, India, and the United Arab Emirates.

A quarter of Kuznetsk coal and coke is exported to the east, relative to the location of the region, to Japan, Korea, China and the Republic of China (Taiwan). East Asian countries acquire both energy and coking coals, and their share in exports is gradually increasing.

Long-term scientific research of domestic and foreign scientists substantiated the scientific, technical and economic potential of the main pipeline transportation of coal products [7-13]. In the context of an increasing rate of changes in the energy sector, a detailed analysis that allows identifying the position of a coal-mining region in the industry segment, adjusting the production and sales strategy, and thereby increasing the economic efficiency of its activities is in great demand [14-15].

There are practical examples of the implementation of projects for the hydrotransportation of coal over long distances in the world: in the USA, Canada, France, Italy, Poland, Austria, China, India, etc. [16]. In Russia, there is also an example of the practical implementation of long-distance delivery of coal through pipes: in the early 90s, the Belovo-Novosibirsk coal pipeline operated in the Kemerovo and Novosibirsk regions, which transported coal in the form of coal-water fuel [13]. The project successfully proved the possibility of transporting coal slurry through pipes over long distances and burning it in power boilers of a CHP plant, but in the conditions of a transitional market economy, the project was closed.

In 2020, it became known that for the first time in many years, the volume of production in Kuzbass decreased at the end of 2019 (251 million tons compared to 255 million tons in 2018). In the winter of 2020, Poland, which was one of the largest importers of Kuzbass coal among the EU countries, abandoned Russian coal. Coal mining enterprises of Kuzbass and the regional authorities have made great efforts to get priority in the transportation of coal along the Baikal-Amur Mainline and Transsib in the eastern direction. At the same time, the carrying capacity of the railways in the eastern direction is not enough for everyone, and the work to eliminate the problems is going far behind schedule, or is completely frozen.

Against the background of the intensification of the shipment of products to the east by the enterprises of the Far Eastern region, the Kuzbass coal companies require a radical reduction in the cost of coal transportation. At the same time, Russian Railways, citing an almost 20% rise in quotations in the ports of the North-West, devaluation of the ruble and non-fulfillment of obligations by coal miners in terms of traffic volumes, will cancel the 12.8% discount on the delivery of coal
products established in March 2020 from October 2020 energy marks for a distance of over three thousand kilometers, which was supposed to operate until the end of the year.

It makes sense to construct a long coal pipeline only in the direction west of the Kemerovo region, since the Irkutsk region and the Krasnoyarsk Territory are rich in their own coal reserves and large hydroelectric power plants operate on their territories.

In addition, one of the main strategic directions for the development of world energy provides for a significant reduction in the anthropogenic load on the environment with its preservation in a state favorable for human life, through the introduction of "green" energy practices [17-20]. Construction and the further need to ensure constant transportation of coal-water fuel through the pipeline would help to solve environmental problems in Kuzbass.

5. Conclusion
Within the framework of the research carried out by the team of authors, on the basis of the analysis of world and Russian experience in industrial production, the ecological, technological and economic advantages of using coal-water fuel were identified and systematized; potential areas of its application are indicated; the analysis of the world practice of coal transportation through pipelines was carried out; a proposal was formulated for a project for the construction of the Kuzbass-Ural pipeline for the supply of coal-water fuel to Western Siberia and the Eastern Urals, and the advantages and disadvantages of coal hydrotransportation in comparison with its railroad delivery were identified.

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