

The Role of Innovative Technologies in Solving Kuzbass Coal Industry Geo-Ecological Problems

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Abstract – The coal mining industry is fundamental for social and economic development of the Kemerovo region (Western Siberia, Russia). This is due to the fact that on the territory of the region the Kuznetsk coal basin is located with unique grades of coal and high coal-bearing strata on a relatively small area. In addition, much of the Kuznetsk coal is suitable for the development of a highly efficient open pit mining, which creates prerequisites for further development of the region. On the other hand, intensive development of the coal mining industry of Kuzbass makes great environmental pressure, and worsens ecological situation in the region as a whole. The article provides a brief analysis of the environmental risks associated with rapidly developing coal industry, and offers exemplary ways of their decreasing.

Keywords – coal industry, geo-ecology, mining, water bodies, Kuzbass

I. INTRODUCTION

The coal mining industry is the basis for the Kuzbass economy [1, 2]. In order to assess its role in the industrial, economic and social life of the Kemerovo region, we can introduce the concept of "mono-region", by analogy with mono-town. Almost every Kuzbass town has a certain relation to coal industry - mines, open pits, coal processing plants are located throughout the area, despite the fact that the area of the Kuznetsk coal basin is almost four times smaller than the area of the Kemerovo region [3, 4]. Such intense concentration of industrial enterprises creates a significant anthropogenic impact on the environment.

II. MATERIALS AND METHODS

The main environmental problems of the region are associated with exposure to the aggressive influence of mining companies which means emissions of large quantities of gas from the massive explosions, spoiling of land and fertile soil, disturbing the hydrological regime of the rivers, the depletion of underground aquifers, and discharging significant amounts of industrial wastewater [5, 6].

Thus, a particularly significant impact is made by mining on land-wide resources and hydrosphere. A large part of land loss is caused by the external dumping and sewage treatment plants formed as the settling lagoons and ponds for sewage treatment. Hydrosphere damage is done, first of all, by discharging untreated mine and open pit wastewater into surface

waters and violation of the hydrological regime of groundwater.

The total coal reserves taken by coal seams thickness, ash and generally accepted condition are estimated as 724 billion tons to the depth of 1800 m. This makes Kuzbass one of the largest coal-producing areas in the world. At the beginning of the 2000s on the government's balance there were about 57 billion tons of coal, explored by industrial categories to the depth of 600 m, including 42.8 billion tons of coking coal [7]. Thus, this resource base allows increasing rapidly the volume of coal production in the basin. However, at present time environmental problems caused by the development of Kuzbass coal industry not only decrease the quality of life [8, 9], but also slow down development of regional economy, and above all - the coal industry [10].

According to the Strategy of Social and Economic Development of the Kemerovo Region up to 2025, the volume of coal production should reach 255-300 million tons (under different scenarios), and by 2030 - 275-330 million tons. However, according to the results of research made by the Mining Institute of Siberian Branch of the Russian Academy of Sciences, the maximum annual amount of coal mined by open pit and underground methods should not exceed 210-225 million tons, considering implementation of technological, seismic, transportation, environmental, energy, and demographic restrictions [11].

III. RESULTS

Development of the Strategy of coal industry should consider potential risks of increasing the volume of coal produced by both open pit and underground mining, including the environmental risk. This is especially important if we take into account the unstable geopolitical situation in the world and the crisis of the petroleum industry [12, 13]. From technological point of view, oil and gas industries may have a certain advantage over the coal industry due to the possibility of the dynamic adjusting of crude oil and gas output [14, 15]. The coal industry is unable to respond so flexibly to all sorts of negative factors, so there is a tendency to concentrate coal production in the open pits while their technological features allow adjusting of their output to fluctuations in the demand on the coal market, as compared to the mines [16].

Thus, in the last decade the share of coal produced by open pits in Kuzbass increased significantly compared to the

underground mining. While in 2000 the share of open pit mining did not exceed 40%, in 2015 open pits mined up to 70% of Kuzbass coal. There is also a reason to believe that at least for the next few decades the tendency of advancing development of open pit mining will remain. This is due to many factors: safer mining operations in an open pit compared to underground mining; lower costs for construction of sections and proceeding open pit mining; relatively low coal production costs. Therefore, the main environmental problems and negative phenomena in Kuzbass are connected with open pit mining.

Of the total amount of land disturbed by open mining, about 75% are quarry fields and dumps, and the rate of the area used for external dumps is more than 40% of the total dumping area. This is explained by the fact that the most common currently used system of open pits development is deepening and extending. Under this system of development, the main part of the overburden is transported outside the open-pit field to external dumps. Also the unfavorable mining and geological conditions of many coal seams in Kuzbass should be noted: in the north of Kuzbass the coal fields bedding is predominantly inclined, and the dip angle varies from 16 to 50°. In the central part of Kuzbass the dip angle varies from steep (50- 90° in the west) to inclined (16-30° in the east). In the south of Kuzbass the dip angle of coal seams varies from flat (3-14°) to inclined (15-35°).

IV. DISCUSSION

All coal deposits of Kuzbass region are diverse by seams' dip angle, although there are differences. In the deposits of the Northern Kuzbass inclined bedding of seams prevails (65% of the total number), on the fields of the Central Kuzbass there is a steep bedding (97%). The dominance of steep and inclined seams in these areas is due to the presence of bow areas and disjunctives. For the Southern Kuzbass deposits the steep seams are absent, the proportion of inclined seams is 25%, flat - 75%.

As can be seen from above, sloping and steep bedding coal seams are dominating, i.e. the least favorable conditions for mining from environmental point of view.

Over 30% of disturbed lands are the quarry fields. Such significant value is due to the fact that, firstly, mining on almost all open pits has not reached its end position yet, and secondly, it is not possible to restore spoiled surface until the completion of mining at a particular pit. To solve environmental problems caused by Kuzbass coal mining the following complex of measures is needed:

1. Introduction of environmentally friendly coal technologies (hydraulic borehole mining, etc.);
2. Development of technology of accelerated (phased) restoring of land spoiled by open pit mining;
3. Development of land saving technologies for open pit mining especially with the internal dumping.

The start of the activities listed above is the mission of not one year. But in the long run they can improve the environmental safety of open pit mining. To help solving environmental problems of the Kemerovo region, the Kuzbass indus-

trial park was established in 2007 in Kemerovo. Its total area is 46.8 thousand m², including industrial and business centers of 16 thousand m², the exhibition center of 19 thousand m², laboratory facilities of 7.2 thousand m², experimental plant - 4.6 thousand m².

The total amount of investment in the construction and reconstruction of the Kuzbass industrial park is estimated at 3.173 billion rubles, including 643 million to build the necessary infrastructure. Considering the specificity of the Kuzbass industrial park, the focus of its innovation activity has been made on the technological innovations that are intended to facilitate the creation of innovative enterprises in coal processing, the formation of the system of financial institutions to support science (non-budgetary Technological Development Fund, a Venture Fund, a Fund of Small Innovative Businesses) and the implementation of advanced scientific research results in a network of small and medium enterprises.

The main element of the Kuzbass industrial park innovation system is supposed to be a Business Incubator. Its primary target is a creation of new innovative business units which are able to develop start-ups after the successful beginning of production of high-tech products. The success of innovative component of Business Incubator would contribute to the positive experience in creation of innovative units in Kuzbass. Currently there are two business incubators in Kemerovo, urban innovation and technology transfer centers. Two existing business incubator with the total area of 1700 square meters have been established with the assistance of the Kemerovo City Administration and the Small Business Support Fund.

The activity of key Kuzbass industrial park residents is focused on reducing environmental damage caused by mining companies. In particular, from the beginning of the Kuzbass industrial park functioning, the following innovative projects in the area of environmental safety were supported:

1. The design and production of complex plants for physical and chemical treatment of waste water using membrane technology. The purpose of this project is the creation of plants for the fine treatment of house holding, mining, industrial and storm waste water using membrane technologies, including reverse osmosis module.
2. The development of a complex approach to opening of methane-and-coal deposits of Kuzbass for optimal simultaneous extraction of coal-bed methane and coal to replace the natural gas which has been purchased from northern regions. The development of methane-and-coal holes has been conducted with the unique drilling technology and equipment designed to meet the geological conditions of Kuzbass. Currently, six holes are under pilot operation in Kuzbass. Advance degassing of coal seams makes it possible not only to obtain valuable raw material - methane, but also ensures the safety of miners' labor.
3. High-tech construction of new and reconstruction of existing generating capacities of the Kemerovo region on the basis of modernization and introduction of new equipment, technologies, processes and management systems.

4. The development and serial production of gas analyzers "GaSense". Portable gas detectors "GaSense" are designed to measure the gas volume fraction of methane, oxygen, carbon monoxide and dioxide. They also can be used in sanitary and technological control of air pollution in coal enterprises to control the excess of maximum permissible concentrations of methane, oxygen, carbon monoxide and dioxide in the air of the working areas in accordance with the requirements of SR 05-618-03 "Safety regulations in coal mines" (the Russian Federation).

5. The development and organizing of production of the devices to create an axial cavity in blasthole charge for increasing drilling-and-blasting operations efficiency and reducing the negative environmental influence of blasting.

6. The construction of a plant for liquefied natural gas of small-tonnage production and creating infrastructure for its consumption. The purpose of this project is an effective organization of direct transport gasification process and its continued service on the basis of local service companies, attracted for transferring such experience.

7. The organization of the integrated low-grade wood processing, the plant of coal waste briquetting constructing. Coal waste briquetting includes technology that allows obtaining a product (so called "pellets") of uniform composition and geometrically correct shape without binders' addition.

8. Processing of liquid and solid stale coke production waste with sintering plasticizer extraction, which can be used as a sleepers-impregnating oil and as a binder premix in coal mines.

Let us proceed to the assessment of the impact of mining on hydrosphere. The main source, transporting pollutants into the surface water bodies adjoining to the segments of mining coal mines, is quarry water resulting from massive extraction of groundwater of developed coal seams for the purpose of dehumidification. The main pollutants of open pit mining waste water directed from the territory of pits to the reservoirs are suspended solids and oil. However, the qualitative composition of mining waste water in each of Kuzbass open pit is specific and depends on the formation conditions, climatic factors and mode of mining of coal seams within the boundaries of quarry fields. Reducing the level of anthropogenic impact on water bodies adjoining to the territories of Kuzbass coal open pits is one of the urgent problems of ecologically safe use of water [17, 18].

The problem of sewage water treatment at the mineral deposits with open pit mining involves great difficulties. Due to the permanent strengthening of the requirements for the quality of discharged wastewater, its treatment in settling ponds does not ensure the achievement of the MPC indicators. In addition, these treatment facilities occupy large areas of land. Also it should be noted that open pits generally have several points of water disposal distancing from each other during the development of mining. Thus, for example, JSC "Coal Company" Kuzbass Razrez Ugol" has 32 places of water use, taking into account the fact that the structure of the company consists of 7 open pits.

The process of open pit waste water purification using filter arrays filled with overburden (mining wastes) is rather well known. At present time numerous studies are conducted, and their results allow asserting that this technology should be used for waste water treatment not only from the suspended solids, but from other contaminants - petroleum, etc. In our opinion wider implementation of this technology will allow efficient recycling of currently usable materials - empty overburden (in addition to providing treatment to effluent discharge standards). In addition, it is very important to take into account the principle of import substitution, so using artificial filter arrays for quarry waste water treatment would eliminate the need of purchasing expensive purifying equipment.

Currently, a large part of the existing and constructing Kuzbass open pits use artificial filter arrays to purify wastewater. Considering the growth trend of the share of Kuzbass coal mined by open pits and the consequent increase of discharged waste water further research is needed to improve the environmental safety of open pit mining operations. Industrial inspection of wastewater treatment using artificial filter arrays of overburden was carried accordingly to recommendations of T.F. Gorbachev Kuzbass State Technical University on JSC "Coal Company" Kuzbass Razrez Ugol" enterprises including "Krasnobrodsky coal open pit" (Novosergeevsky and Krasnobrodsky coal deposits), "Kedrovsky coal open pit", and Kedrovsky motorpool. The research involved sampling and analysis of wastewater samples before and after treatment in the filters array. Filter arrays were constructed from overburden, developed in the relevant open pit mine.

All studies showed a decrease in the concentration of practically all pollutants in quarry water after filtering through the artificial arrays - suspended solids, oil and manganese, lead, strontium, barium, titanium, aluminum, iron, silicon, copper, nickel and zirconium [19, 20].

V. CONCLUSIONS

So the development of coal mining - a key industry of Kuzbass, main budget revenue source and high-paying jobs, is held back by the complex of unsolved environmental problems. In future, these problems related to the negative impact of mining enterprises on water, land and air resources, can become a significant obstacle [21] to the implementation of the Strategy of Social and Economic Development of the Kemerovo Region. Their solution requires cooperation between regional enterprises, universities, the Kuzbass industrial park and the Administration of the Kemerovo region in the development and implementation of innovative technologies of minerals extraction and processing.

ACKNOWLEDGEMENTS

The authors express their gratitude to the staff of Open Pit Mining Department of the T.F. Gorbachev Kuzbass State Technical University, the staff of Economy Department of National Research Tomsk Polytechnical University.

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