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Research

SOME ASPECTS OF TECHNOLOGY IMPROVEMENT OF UNDERGROUND COAL GASIFICATION

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ABSTRACT

The importance of the technology improvement of underground coal gasification (UCG) is stipulated by the increasing energy demand of the national economy of the country. A new wave of interest in the UCG can be explained by some reasons. The most important of them are the fast-growing prices of oil, natural gas, limitation of their resources, growing scales of the environment damage from the open cast or underground mining of coal and its use in the heat and power plants. The processing of the extracted coal into the more "pure" types of liquid or gaseous fuel can eliminate only the part of this damage and still it costs much. At the same time, the possibilities to improve the efficiency of the underground gasification of the coal layers and complicated physical and chemical processes of UCG are not properly studied yet. The results of the analysis of the main stages of the UCG technology development were represented, as well as the complex of the domestic and foreign innovative scientific and technical and design solutions. The possibilities and the objects of application of the downhole power technology of the joint development of geothermal and mineral resources were demonstrated. The directions of the modern development of the downhole methods of coal processing and some problems of realization of the projects of underground coal gasification of the new generation were distinguished.

INTRODUCTION

The change of the economic growth model in Russia from the production increase due to the increase in the load of the earlier introduced production facilities (recovery growth) to the development on the base of the large-scale construction of the new facilities (investment growth) has not led to the limitation of the energy consumption (Monaghan, 2007).

Thus, the level of energy consumption per unit of the comparable GDP of Russia is approximately four times higher than in the USA. Even the decrease of the energy consumption of GDP when transferring to the model of the investment growth activated the demand for energy because the outperformance of the investments in comparison with the growth of GDP determines the faster development of the energy consuming branches of industry.

The growing energy demands of the national economy of the country require the large-scale introduction of the achievements of the scientific and technical progress and innovations.

The attitude to solve only critical problems of energy consumption when the situation in the coal raw material market is changed, for example, while the world prices for oil and gas complex products are increasing, led periodically to the growing interest in the underground coal gasification technology.

The basic principles of the underground coal gasification technology were formulated already in the beginning of the previous century.

Despite the leadership of the Russian scientists in the field of the fundamental research and creation

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of the theoretical bases of the physical and chemical processes of coal combustion and gasification, the following foreign countries: Japan, Germany, France, USA, Australia, China and Canada - are leading in creation and implementation of these technologies. The interest to the gasification technology is growing in South Korea, India and many other countries.

In the 1970-1980s in the USA, the projects Hoe Creek, Hanna, Carbon County, Centralia, where the technologies of the controlled drilling and air blast from the mixture of oxygen and water steam under high pressure were applied, could significantly extend the field of application of the more qualitative UCG gas. However, due to the extremely high air blast pressure, the projects were completed with the pollution of the underground waters by benzene and phenols (Komarov, 2012).

In China, now there are about ten enterprises using UCG with a combined technology based upon the shaft preparation of the coal blocks.

According to the data of the author of the article (Komarov, 2012), in 2010 one large South African energy holding Eskom, using the experience of the company Ergo Exergy, started the implementation of the pilot UCG project on the base of air-blast with a capacity of 21 MW of the synthetic natural gas, the main aim of which was to construct the demonstrational plant with a capacity 350 MW by 2014-2015. Ergo Exergy in Canada started the project in the Chinchilla town, Australia (1999-2003), which was the beginning of the development of the Australian company Linc Energy that became the world leader in R&D and commercial implementation of the UCG technology. In 2007, Linc Energy purchased the Angren station in Uzbekistan that still functions. The UCG technologies of these companies advanced rather far and the risks connected to the realization of the projects were minimized to a large extent. The controllability of the gasification process of Link Energy is confirmed by the Australian Department for Environment and Heritage Protection (DEHP) and by regular measurements under the supervision of DEHP during 13 years of work of the gasifier.

Russia also possesses the significant potential in the development of the traditional and innovative technologies of the coal processing by the downhole methods.

By the beginning of the 1960s, the idea of the underground gasification started to be realized on some stations of the former Soviet Union. In the experimental industrial mode, millions of tons of coal were processed and the billions of cubic meters of gas were obtained in the units of Moscow and Shatsk (Moscow lignite basin), Angren (Uzbekistan) and Sinnelnikovs (Dnieper basin) of the Podzemgaz station that work on the lignite coals and also the South-Abinsk (Kuzbass) and Lisichansk (Donbass) of the Podzemgaz station that work on the bituminous coals (Kreynin, 2004). For the period from the 1930s till the 1960s, about 10 billion US dollars in the prices of 1976 were invested in the development of the UCG technology.

The history of the domestic and foreign experience of the development of the underground coal gasification, the peculiarities of the process, the recommendations of its improvement, and the complex of new scientific and technical and design solutions are represented in many publications (Arens, et al., 2007; Belov, et al., 2010; Vasyuchkov, et al., 1997; Dyadkin, et al., 1993; Dyadkin, et al., 1993a; Dyadkin, et al., 1994; Zorya and Kreynin, 2009; Zorya and Kreynin, 2009a; Zorya, et al., 2009; Kornilov, 2004; Kreynin, 2004; Komarov, 2012; Karasevich, et al., 2009; Proshunin and Poturilov, 2010; Smirnova and Solovyov, 1982; Solovyov, et al., 1995; Monaghan 2007; Sonel Company. (n.d.)), etc.

Using its own and foreign experience Russia has the possibility to develop this technology at a higher technical level.

In the modern development of the downhole methods of coal processing, the following trends can be distinguished:

- improvement of the traditional technology of the underground gasification at the depths of up to 300 meters;
- development of the coal beds combustion methods and utilization of the physical heat of the combustion products;
- gasification (combustion) of the coal beds at the depths of 1000 meters and more;
- complex approach to the development of the energy and chemical resources of the deposits (combination of the underground gasification with other technologies).
- combustion of interlayers of the caking coals for the unloading and safe processing of the outburst-prone seams and seams liable to rock-bumps;
- development of the technologies oriented to the production of the synthetic liquid fuels on the base of the synthetic natural gas of the underground coal gasification that are not

available for the development by the traditional methods.

The new scientific and technical and design developments are directed to the decrease of the negative environment consequences of the UCG implementation, the improvement of the structure of the ground complex, underground gas generator and the technology of the coal layer gasification, the decrease of the non-productive losses of heat, the solution of the problem of preparation and use of the energy gas.

In the works (Zorya and Kreynin, 2009; Zorya, et al., 2009; Karasevich, et al., 2009), the investment attractiveness of the wide industrial application of the enterprises "UCG-TPP" with a power capacity of 25, 60, 300 and 600 MW with the payback period of the capital costs into the UCG enterprise of 2-3 years was stipulated. The main element of the offered technology is a module of the underground gas generator with a movable gasification channel. The new level of design solutions, the possibility to produce the replacement of the natural gas while performing UCG using the steam-oxygen blast, the controllable system of coal bed gasification and some other technical solutions allow to consider the offered technology able to compete with the modern technologies of the shaft and open cast coal mining and also the latest developments of the foreign countries.

The specialists of the Far East State Technical University summarized the experience of the existing design developments, literature sources and patent information in the complex method of formation of UCG stations (Belov, et al., 2010). Together with the underground gasification, it is offered to process the industrial and solid household wastes into the combustion gas to obtain the electrical power and heat. The essentials of such technology are patented.

The article (Proshunin and Poturilov, 2010) describes the method of generator gas preparation of the underground gasification of lignite and bituminous coals, providing for its dry cleaning at the temperature exceeding the condensation temperature of high molecular hydrocarbons-coal tar and further combustion of the prepared gas, which decreases significantly the costs of the UCG unit construction. Besides, the offered method provides the improvement of the ecological indicators of the underground gasification complex and the increase in the heat potential of the generator gas.

The efficiency of the underground gas generators can be increased due to the complex approach to the processing of coal by the shaft methods and increase in the economic efficiency of development of the energy and chemical resources of the deposits.

The 1980s were the period of the intensive development of the geotechnological methods of mining of minerals, the formation of the geothermal circulation systems with collectors of various type and also creation and realization of the project of new resource saving technologies of the complex mining of energy resources.

METHOD

In the Saint Petersburg Mining University, the development of a new shaft energy technology of the thermal and chemical processing of coal beds started in 1979.

The increase in the mining depth of coal deposits in the areas with the increased geothermal gradient (at the big depths, the outbalance coal reserves and resources of the geothermal energy are combined in the same space) and the formation of the geothermal collector above the sites of the deposits developed by the geotechnological methods of mining determined the creation of the idea and the possibilities of formation of the technology of combined development of the geothermal and mineral resources.

The use of solid oxidizers (Solovyov, et al., 1995) in the offered technology for partial combustion of non-working protective layers allows to decrease the safety of mining of outburst-prone seams and seams liable to rock-bumps of coking and chemically valuable coals.

The offers of the Mining University (Dyadkin, et al., 1993; Dyadkin, et al., 1993a; Dyadkin, et al., 1994; Smirnova and Solovyov, 1982; Solovyov, et al., 1995) allow to use the UCG gas not only as an energy raw material but also as a raw material for the chemical industry, to extract the associated valuable elements, to decrease the losses of coal in the resources, to use the physical heat in gas and heat accumulated by the surrounding mining rocks in the period of development of the coal bed, geothermal potential of the big depths and also to use the developed space for waste burring of various and own production facilities.

RESULTS

The objects of application of the downhole energy technology of thermochemical processing of the coal beds (Dyadkin, et al., 1993) are:

- deep bed horizons of the energy coals, combusted to achieve the working steam of the

high parameters for the turbines of HPP, in the products of which, beginning from the depths of 1.5 km to 2.5 km, the main primary source is the geothermal energy of the hot rocks (geothermal and coal technology);

- layers of different power with high ash, high sulphur, low calorie or water-encroached coal, at the complete combustion of which at the presence of water the steam of high parameters is obtained, and it is offered to process the solid household wastes and ash residue, slag and wastes of chemical processing of liquid and gas flows and to fill the mined-out area with the coal gasification with the empty rocks completely;
- outburst-prone seams and seams liable to rock-bumps of coking coals, for the unloading and safe mining of which the layer system of cracks is made in these single layers or close underlying layers and interlayers of the non-working capacity; open-cast mining on case of high ash, low-calorie, sulphurated coal layers-to replace the ash, slags, utilization of the valuable chemical components with wastes in-situ;
- moderate depths up to 1.5 km-for increasing the coefficient of efficiency of extracting the heating capacity of the coal beds, utilization of the valuable chemical components and heat accumulated in the resources during gasification (combustion), burying wastes, mining protective layers;
- depths from 1.5 km to 3.5 km-for extracting the geothermal energy and heat accumulated by the rocks and emitted during the gasification (combustion) process, utilization of the valuable chemical elements, and burying wastes.

DISCUSSION

Using the complex approach and combining several technologies, the disadvantages of the unprofitable process of underground gasification, for example, the developments of the outbalance reserves of the coal beds at the big depths, become an advantage of this process. It is stipulated by the fact that while increasing the mining depth of the coal resources, the bigger share into the extracted heat carrier is made by the heat of rocks and this promotes the decrease of the capital intensity per conditional unit of fuel extraction despite the increase in the capital costs for the formation of the complex of extraction and processing of coal and geothermal resources.

Despite the available experience and many works on theoretical analysis and economic feasibility of the traditional and modern variants of technologies of the underground coal gasification and geothermal technology, the new ideas and design solutions do not receive the industrial distribution in Russia.

CONCLUSION

While implementing the projects of the underground coal gasification, there are still many unsolved natural, technical, social and political problems. Ecological risks, high degree of the process uncontrollability, insufficient stimulus for investments, lack of qualified specialists and many other problems, as the experience of Linc Energy shows, can be minimized to a great extent. But the grounding of the industrial concentrations is impossible without the state support by the legislative and executive powers.

In the article of the British analyst Andrew Monaghan from OSU "Focus on Coal", the main tendency of the increase in the coal share in the energy balance and the growth of its value for the energy strategy of Russia is noticed. However, in the author's opinion, "… the remaining problems connected to the absence of corporate and bureaucratic discipline together with the corruption make the implementation of any plans more difficult".

Despite the complicated nature of such situation in the field of the underground coal, the interest in the downhole coal gasification is still strong.

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