

Prospect Analysis of Underground Gasification in Deep Oilfield for Natural Gas Exploitation Enterprises

Zhiyong Cheng

Daqing Oilfield Co., Ltd. Gas Production Branch, Daqing, Heilongjiang 163000, China

Keywords: Natural Gas Exploitation Enterprise; Deep Oilfield; Underground Gasification; Prospect

Abstract: Coal measures are well developed in petroliferous basins in China, and coal resources in deep oilfields are abundant. It is preliminarily estimated that gasifiable coal is three times the amount of conventional natural gas resources. Natural gas mining enterprises have certain advantages in resources, horizontal well drilling and completion, production measurement and control technology based on coiled tubing, comprehensive advantages of building underground gas storage in deep oilfields, market support advantages and natural gas substitution benefits to drive them to play their own advantages in technology, pipeline and market integration, according to different needs and corresponding technological maturity. To develop underground coal gasification business in deep oil fields by optimizing the path can effectively and cleanly develop and utilize a large number of coal resources, alleviate the shortage of natural gas supply and improve the self-sufficiency of domestic natural gas.

1. Introduction

Underground gasification in deep oilfields is a new technology for the controlled combustion of underground coal, the generation of combustible gases through the thermal and chemical action of coal, the comprehensive development of clean energy and the production of chemical raw materials. The essence is that only the energetic components in the coal are extracted, and the pollutants such as ash are left in the well. The deep gas oil underground gasification technology integrates various processes such as well construction, coal mining and transformation, which greatly improves the utilization efficiency and utilization level of coal resources. At present, China's energy industry faces severe challenges of high dependence on oil and gas. In 2018, the external dependence of oil and gas has reached 71% and 43% respectively. With the arrival of peak energy demand, the external dependence is expected to further expand. The underground coal gasification energy density is large, and it has strong correlation with the petroleum and petrochemical industry. It will create a net zero-emission demonstration of petroleum and petrochemical circular economy through the industrial chain of "coal underground gasification-hydrogen-CO₂ enhanced oil recovery and storage in petrochemical refinery". The district can not only clean up and utilize a large number of deep idle coal resources, but also alleviate the tight supply of natural gas. It can also effectively solve the environmental problems caused by CO₂ emissions from coal combustion in China, and better reserve resources and technology for the "hydrogen economy" era. To open up a new path for China's "clean, low-carbon, safe and efficient" modern energy system.

2. Underground gasification technology in deep oilfields

Underground gasification in deep oilfields is a chemical coal mining method that converts the coal resources of a petroliferous basin into a combustible gas in the original natural state and transports it to the ground. The process is realized in the gasification channel of the underground gasifier. The gasification principle is the same as the principle of surface gasification. When the gasification agent is ventilated from the gas inlet passage, the oxygen in the gasification agent first reacts with the carbon in the coal seam to generate a large amount of heat. The coal seam is hot and heat storage, and the generated carbon dioxide and water vapor meet the hot coal seam in the

reduction section. At a sufficient temperature, the carbon dioxide is reduced to carbon monoxide, and the water vapor is decomposed into hydrogen and carbon monoxide.

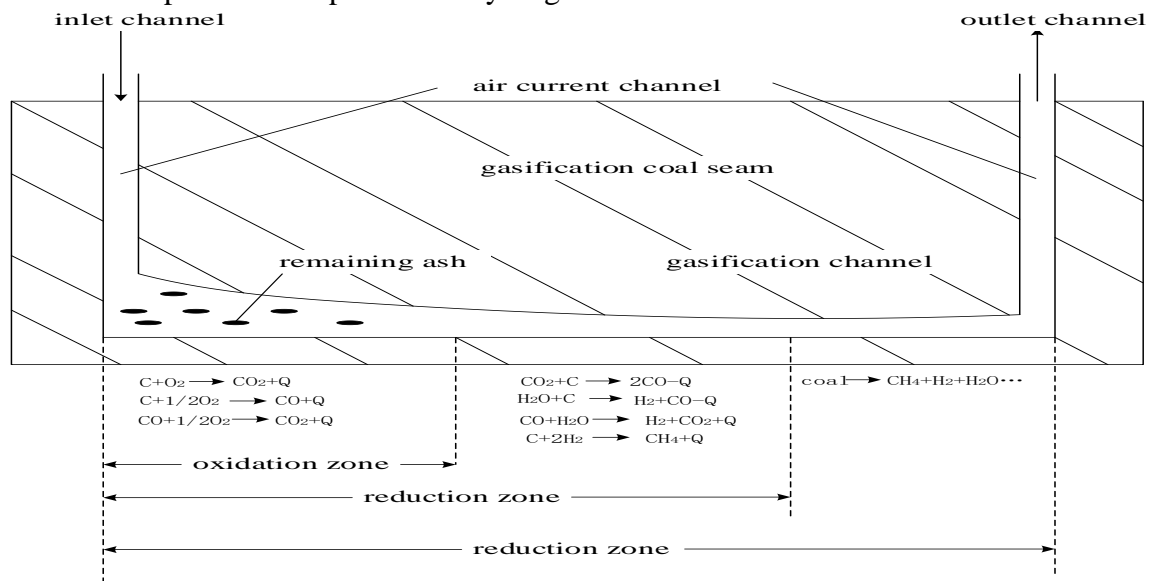


Fig. 1 schematic diagram of underground gasification

The underground gasification process is mainly realized in the gasification channel of the underground gasifier. The whole gasification process can be divided into three reaction zones: redox and dry distillation (Fig. 1). From the chemical reaction point of view, there are no strict boundaries in the three regions, and there are coal pyrolysis reactions in the oxidation zone and reduction zone. The division of the three zones is only the relative strength of oxidation, reduction and pyrolysis reactions in the gasification channel. degree. After the three reaction zones, a gas containing combustible components, mainly hydrogen, carbon monoxide and methane, is generated, and the gasification reaction zone gradually moves toward the gas outlet, thereby maintaining the continuous progress of the gasification reaction process, and the gas of the gasification channel The wall continues to burn and advances, leaving the remaining ash and residue left in the goaf.

3. Development Status of Underground Gasification Technology in Deep Oilfields

The Soviet Union was the earliest country in the world to conduct field tests of underground gasification, and it was also the most successful country in the application of underground gasification industry. In 1932, the world's first well-type gasification station was established in Dunbas. By the end of the 1960s, 27 stations had been built. In recent years, Russia has carried out a lot of research on underground gasification, from the past penetration technology to directional drilling penetration technology, in order to achieve long-distance penetration. In terms of gasification technology, they have carried out experiments on gasification agents. They have changed from low calorific value gas obtained from air influx to medium calorific value gas obtained from oxygen influx, which has greatly improved the level of underground coal gasification technology, especially power generation by underground coal gasification gas. They have achieved good economic and social benefits. They are in the leading position in the world in the development and utilization of this technology.

The underground gasification test in the United States began in 1946. First, the test was carried out in the shallow coal seam of Alabama. The calorific value of the gas reached 0.95. In the 1970s, the United States organized 29 universities and research institutes to conduct large-scale and planned experiments in Wyoming, using oxygen-enriched steam as gasifier, and to generate electricity and ammonia. By the 1980s, technological achievements in increasing furnace type, increasing production capacity, reducing cost and increasing calorific value of gas were obtained. The U.S. Department of Energy has announced that in the event of another energy crisis, the technology will be widely used in the production of calorific value gas in the United States to

address urgent needs.

Britain, Japan, Poland, the Netherlands, Germany, Canada, Belgium, France and other countries have also conducted experimental studies on underground gasification technology in accordance with the characteristics of their coal seam occurrence conditions, and have achieved rich results.

China began relevant research as early as the 1950s, and began to research and test most actively in the 1990s. With the support of the national "Eighth Five-Year Plan" scientific and technological research project and "863" project, more than a dozen shallow coal underground gasification pilot projects have been carried out continuously, but mostly in artificial mining roadways and shallow coal seams. Since the 21st century, along with the introduction and development of coal seam horizontal well technology and coiled tubing technology, China has started the research of coal underground gasification technology in modern sense and field test. At present, the research of laboratory and field tests has gradually shifted to industrial demonstration production and application, and the underground coal gasification technology with independent intellectual property rights has been developed. Supported by the national "973" project, the pilot project of Ulanhabu underground coal gasification mine was carried out by New Austria Group during 2007-2015. Three underground coal gasification stations have been built successively. The coal chemical industry now has five factories with total assets of 65 million yuan and 680 employees. Its annual output value is 540 million yuan, its sales revenue in 2010 is 200 million yuan, and its annual sales revenue in 2015 is 300 million yuan. It is estimated that the annual sales revenue in 2020 will be 400 million yuan.

Table 1 Comparison of underground gasification in different countries

country	place	time	component						heat value (mj/m ³)
			O2	CO2	CO	H2	CH4	N2	
US	Tall gas	1985	12.3	6.2	0.5	0.78	0.42	79.4	1.88
	Hanna	2005	0	35.8	7.45	5.64	8.21	45.6	5.27
Britain	Newmens Pinney	2009	0.2	18.5	4.1	7.6	1.3	58.4	2.31
Italy	Validano	2003	0.3	14.5	4.6	17.2	2.8	55.3	4.32
Belgium	Bouardam	2008	0.06	15.4	45.8	24.6	1.4	2.6	8.78
France	Delada	1994	0	14.6	2.5	17.4	4.8	56	3.56
	Donbass	2006	0.4	11.2	14.5	12.3	1.4	52.3	3.56
Soviet Union	Moscow	1982	0.2	11.4	7.5	13.2	1.3	50.2	2.6
	South Abinscu	1988	0	5.4	21.3	15.4	1.45	40.6	5.89
China	Hegang	1994	0.5	14.3	17.0	13.2	0.5	11.5	3.52
	Xuzhou	2001	0.5	2.8	10.3	54.6	12.4	1.8	14.6

4. Comprehensive Analysis of Underground Gasification Industry in Deep Oilfield

Underground gasification technology in deep oil field can fully recover and utilize scrap coal resources. Underground gasification technology in deep oil field can recover coal resources abandoned by traditional mining technology, reduce surface environmental damage and avoid air pollution. Mine mining will cause surface subsidence, and waste rock will occupy farmland and destroy the environment. The ash from underground coal gasification combustion is stored underground, and the coking ring formed after combustion can bear ground pressure by itself. The amount of surface subsidence will be greatly reduced, which is conducive to environmental protection and ecological balance. Underground gasification is a clean coal combustion technology, which can fundamentally solve the problem of air pollution. To provide raw materials for the development of coal chemical industry. Underground coal gasification technology is simple, cost-effective, fast-acting, pipeline transportation, and can be used as chemical raw materials. It is an important way to convert abandoned coal mines into production in China. Compared with other clean coal utilization technologies (Table 2), underground coal gasification has broad prospects in coal mining and utilization.

Table 2 Economic comparison between underground gasification project and underground coal mining

project	underground mining	underground gasification	increase and decrease	difference value/%
Total capital investment	384000 dollars	84485 dollars	-299539 dollars	-78
Investment per ton of coal	1.02 dollars	0.24 dollars	-0.86 dollars	-78
Construction time	2~3 years	1~2 years	1 years	
Production costs	0.28~0.34 dollars	0.12 ~0.13dollars	-(0.17~0.22)dollars	-(61~63)
Production efficiency	40~45ton per month	180ton per month	+135ton per month	
Resource recovery rate	70%~80%	90%	+10%	

5. Advantages of Natural Gas Exploitation Enterprises in Underground Gasification of Deep Oilfields

5.1. The technological progress of natural gas exploitation has created conditions for underground gasification in deep oil fields.

In recent years, in order to effectively exploit and utilize low-grade and unconventional oil and gas resources, petroleum engineering technology has made rapid progress, which will play a key role in the commercial breakthrough of deep coal underground gasification. High-precision three-dimensional seismic exploration technology has been able to accurately identify the distribution of underground oil, gas, coal and groundwater reservoirs; U-shaped horizontal well drilling and completion technology in deep coal seam can ensure accurate borehole trajectory, effectively prevent collapse, and achieve large-scale underground furnace construction; burning oil layer technology has realized the "in-situ transformation" of super heavy oil resources, and heavy oil pyrolysis can be used for reference by coal pyrolysis; The progress of caliber coiled tubing and its matching tools and downhole complex operation technology can provide rich experience for precise guidance and control of underground gasification process. Once commercial breakthroughs have been made in the series of supporting technologies for underground coal gasification, it will effectively break the depth limit of coal development and utilization, activate huge amounts of deep coal resources, convert coal resources into gas in situ, and further synthesize oil and gas on the ground after purification.

5.2. The development of underground gasification in deep oil fields by natural gas mining enterprises can give full play to the advantages of comprehensive development of resources.

In the process of oil and gas exploration, natural gas mining enterprises gradually deepen their understanding of medium and deep coal resources. Coal-bearing strata formed in different periods are widely distributed in the mining right areas of oil and gas enterprises. In the process of oil and gas exploration and development in Ordos, Tarim, Junggar and Erlian oil and gas basins, coal-bearing strata with large area distribution are drilled, and abundant geological and analytical data of coal seams are obtained. For coal and coals with different geological periods and different coal and rock qualities, coal and coals in the middle and deep strata are available. Gasification resources have a certain understanding. Compared with coal enterprises, natural gas mining enterprises have obvious advantages in theory and technology of deep geological exploration due to the different main bodies of resource targets and long-term accumulation. The mature geological comprehensive evaluation technology, geophysical exploration technology series, horizontal well drilling and completion technology, continuous pipe integration technology, high temperature heavy oil thermal recovery technology series, real-time on-line monitoring technology, surface natural gas

purification and treatment technology series of natural gas mining enterprises can lead the development of underground coal gasification industry through oil and gas development matching technology, through targeted improvement and application. In the key links of underground coal gasification, such as site selection, furnace construction, gas injection, ignition and production, micro-seismic monitoring technology is used to monitor the shape and size of coal seam gasification caverns in real time; ignition, injection control and wellbore integrity of in-situ coal gasification technology can be used for reference in ignition and control links of underground coal gasification, which is expected to promote the underground coal gasification project in the middle and deep seams. Substantive breakthroughs have been made.

6. Conclusion

Deep underground coal gasification belongs to "high-precision" technology, which has a long professional span and is very difficult to commercialize. In addition to geophysical exploration, well drilling and completion, chemical engineering, storage and transportation technology and continuous oil pipeline equipment and tools, it also involves integrated innovation of coal geology, hydrogeology, gas power generation, high temperature resistant materials, high temperature and high pressure measurement and control technology. The key technology of business is related petroleum engineering technology. Oil and gas exploitation enterprises have innate advantages. They should actively play a leading role in the industry. With the strong support of relevant government departments, they should further jointly carry out technological research and integrated innovation in multi-industries in order to achieve a breakthrough in the commercialization of deep underground coal gasification and become the leader of deep underground coal gasification technology in China. China's rich deep and ultra-deep coal resources, with the help of underground coal gasification technology, are expected to be effectively exploited and utilized, fundamentally improving the self-sufficiency of domestic natural gas, achieving energy conservation and emission reduction, improving the environment, and realizing the optimization and adjustment of energy structure.

References

- [1] Zhu Jie, Kan Shikai. Prospects for development of under-ground coal gasification [J]. Shanxi Cooking Coal Science & Technology, 2010, 34(7), 54-56.
- [2] Chen Ming. China owns total coal resources of 5.9 trillion tons while the predicted resources of 3.8 trillion tons [J]. Western Resources, 2014(01), 69.
- [3] YONG SHENG, ALEKSEY BENDEREV, DONKA BUKOLSKA, etc. Interdisciplinary studies on the technical and economic feasibility of deep underground coal gasification with CO₂ storage in Bulgaria[R]. Springer Science + Business Media Dordrecht, 2015.
- [4] LIU Shuqin, LIANG Jie, YU Xuedong, et al. Characteristics of underground gasification of different kinds of coal[J]. Journal of China University of Mining & Technology, 2003, 32(6): 624-628.
- [5] SU Faqiang, ITAKURA K I, DEGUCHI G, et al. Monitoring of coal fracturing in underground coal gasification by acoustic emission techniques[J]. Applied Energy, 2017, 189: 142-156
- [6] ZHANG Ming, WANG Shipeng. Technical situation of underground coal gasification in China and abroad and the study progress of ENN[J]. Exploration Engineering (Rock & Soil Drilling and Tunneling), 2010, 37(10): 14-16.
- [7] WANG Zhen, XUE Qing. To fully exert the important role of natural gas in building a modern energy security system in China: An understanding of China's National 13th Five-Year Plan for Natural Gas Development[J]. Natural Gas Industry, 2017, 37(3): 1-8.

- [8] ZOU Caineng, ZHAO Qun, CHEN Jianjun, et al. Natural gas in China: Development trend and strategic forecast[J]. Natural Gas Industry, 2018, 38(4): 1-11.
- [9] Wang Huanxin.Study on the global prospective coal chem-istry based on the developing UCG technology[J].Guang-zhou Chemical Industry,2011,39(3),1 2.
- [10] Du Feng.Analysis and Practice of Coal Underground Gasification Technology in Liaohe Oilfield [J].Petroleum Drilling Technology, 2006, 34(5): 83-86. [12] Zhijun He. LM629-based motor servo control system design [J]. Mechanical design and manufacture .2009 (2) 40-42.