AN OVERVIEW OF THE CHINESE UCG PROGRAM

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ABSTRACT

Coal is the dominant source of energy in China, but about 50% of the coal resource is left underground unmined. Because of this, the "long-tunnel, large section, two-stage" Underground Coal Gasification (UCG) technology has been put forward, and the UCG model platform has been built. Simulation tests are underway and some gasification parameters have been obtained. Five field trials have been completed, which have produced gas with a heating value of about 4.18MJ/m^3. Gas containing more than 40% hydrogen and a heating value above 8.36MJ/m^3 is produced at two-stage gasification.

Key words: UCG technology, Coal gasification

1 INTRODUCTION

Coal is the dominant source of energy in China. It will continue to dominate in the days to come. However, serious environmental pollution, ecological destruction and coal waste, which arise from the traditional mining, transportation, and utilization of coal, cannot be neglected. Because of the limitations of manual mining, about 50% of the coal resource is left underground unmined. This statistic reveals that the abandoned coal resource amounts to 30 billion (10^9) tons, which calls for more efficient and cleaner coal technology and utilization to be adopted. The Underground Coal Gasification (UGC) process readily meets this demand. The UCG Research Center of China University of Mining & Technology (Beijing) (CUMTB) has carried out such research since 1984. Based on theoretical research and model tests, five field trials have been completed.

2 UCG MODEL TEST

The simulation test platform is shown in Figure 1. In the gasifier, there are 4 holes for gas inlet or outlet, 19 holes for measuring temperature (85 spots in the coal seam and roof-bottom rock for temperature measurements can be set), 4 holes for observing the burning and burned-out areas, and 10 spots for pressure and gas samples to be measured. There are three functions: (1) Simulating the UCG process with different coal quality, coal seam obliquity, coal thickness, and coal depth. (2) Testing with different UCG parameters, such as: two-directional blast, assistant-hole blast, pressing-in and

Figure 1. UCG model test platform

absorbing-out. (3) Testing of different gasifier parameters. The supply system of the gasifier consists of blast equipment, O_2 supply, and equipment for H_2O (g) generation. Through an air compressor blast, the O_2 content can be controlled between 21-100%.

The results for simulation tests with lignite, soft coal, and hard coal during the O_2-H_2Og continuous gasification process can be seen in Table 1. In the simulation tests, numerous theoretical parameters are controlled, such as temperature field, concentration field, velocity field, velocity of gasification reaction, extent of burned-out area, stability of the UCG process, technology of measuring and controlling, CO_2 elimination, and CO transfer to generate H_2, and so on.

Table 1. Gas component, heat value, and production rate

Coal type	Gas component %					Gas heat value	Production rate
	H_2	CO	CH_4	CO_2	N_2	MJ/m^3	m^3/kg
Lignite	36～45	20～30	1～5	25～35	1～3	8.5～9.5	1.2～1.4
Soft coal	33～42	25～35	4～10	20～25	2～3	9.6～11	1.8～2.3
Hard coal	35～45	25～35	2～8	25～30	1～3	9.5～10	1.9～2.5

3 UCG FIELD TRIAL IN CHINA

Based on field tests and other UCG technologies at home and abroad, the UCG research center of CUMTB has brought forward the "long-tunnel, large-section, two-stage" UCG technology. The principle of the technology is shown in Figure 2. It is the mixture of shaft and no-shaft gasifier and consists of boreholes, an airflow tunnel, and a gasification tunnel.

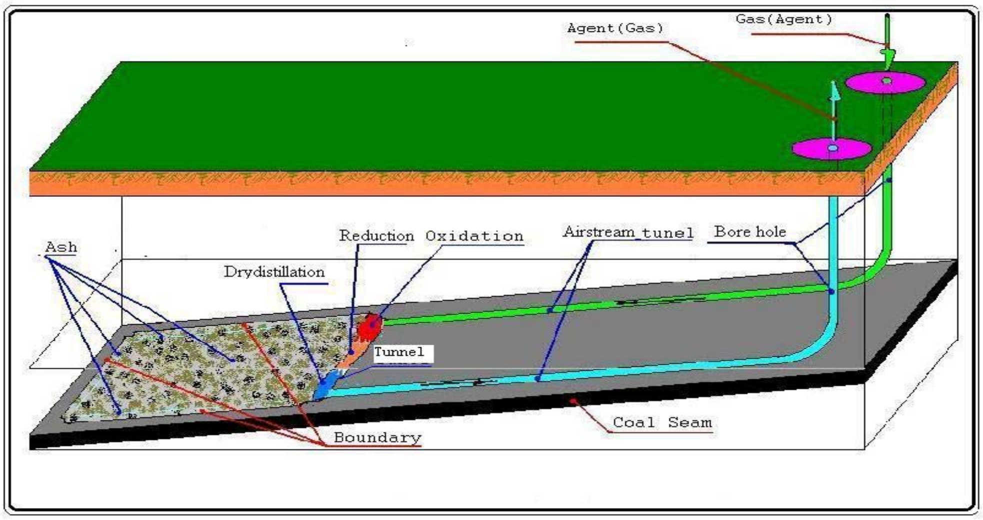

Figure 2. Sketch of the "long-tunnel, large-section, two-stage" UCG technology

Two-stage means that air and water vapor are blown circularly. In the first stage, air is blown into the gasifier to support combustion. In the second stage, steam is blown in, which decomposes when meeting hot coal and then forms underground water gas. In this stage, H_2 concentration reaches about 50% (Liang Jie & Yu Li, 1995). Up to now, five UCG stations have been set up. They are shown in Table 2.

Table 2. Status of the UCG stations

Mine		Xinhe	Liuzhuang	Xinwen	Feicheng	Xiyang
Coal kind		Fat coal	Gas coal	Gas coal	Fat coal	Anthracite
Coal seam feature	Depth, m	80	100	100	80-100	190
	Thickness, m	3.5	2.5-3.5	1.8	1.3-1.8	6
	Obliquity, °	68-75	45-55	25	5-13	22-27
Gas heat value,MJ/m^3		11.83	12.24	5.21	5.09	11.91
Gas component %	H_2 %	58.29	47.14	54.79	17.4	54.30
	CO %	8.59	13.36	9.72	3.83	4.10
	CH_4%	9.28	12.38	8.75	6.22	12.20
	CO_2 %	19.63	20.48	20.75	22.9	20.20
	N_2 %	4.21	6.64	5.21	49.5	9.10
Time of ignition		1994.3	1996.5	2000.3	2001.9	2001.10

3.1 UCG demonstration projects at the Liuzhuang mine

This project belongs to the key scientific and technological project of Hebei Province. The gasifiers have been in operation for more than 5 years, since May, 1996. The gas is piped to nearby factories for industrial boiler use.

3.2 Structure of the gasifier

The #9 and #12 coal layers were selected as the gasification zones. The #9 coal layer is 30-40m from the #12 layer, and there is a semihard sandstone seam between them. The thickness of the #9 coal seam is 3.0-4.5m with roof sandstone and bottom shale, while the thickness of the #12 coal layer is 4-6.5m with roof saprogenic shale and bottom sand shale. The analysis of the coal quality is shown in Table 3.

Table 3. Analysis of coal quality

Coal seam	Water %	Ash %	Volatile content %	Sulfur %	Carbon %	Heat Value MJ/Kg
#9	0.02-0.18	16.25-19.58	28.68-30.01	0.75-0.87	31.71-53.74	23.02
#12	0.01	6.42-9.94	30.37-33.27	0.8-1.72	58.92-60.74	25.12

The U-shape structure was designed, and two gasifiers were built in the #9 and 12# coal seams respectively.

Each has two assistant boreholes between the injection and production boreholes. To ensure safety and seal conditions, insulation bands were constructed on both sides and at the bottom of the gasifier, using coal ash and cement as filling material. The sketch of the gasifier structure is shown in Figure 3.

Figure 3. Sketch of Liuzhuang UCG gasifier

3.3 Gas production and utilization

The gasifier in the #9 coal seam began to work on May 18, 1996 and lasted 81 hours after ignition. Air-based gasification was first undertaken in this trial. The amount of airflow was adjusted to sustain stable gasification. The gas composition, heat value, and flow of air gas are shown in Figures 4 and 5. The heat value of the air gas is about 4.18MJ/^{m3} and can meet the needs of boiler burning. Two-stage gasification was tested to obtain gas with middle heat value and high H^2 concentrations up to about 50% (Liang & Yu, 1996). See Table 4.

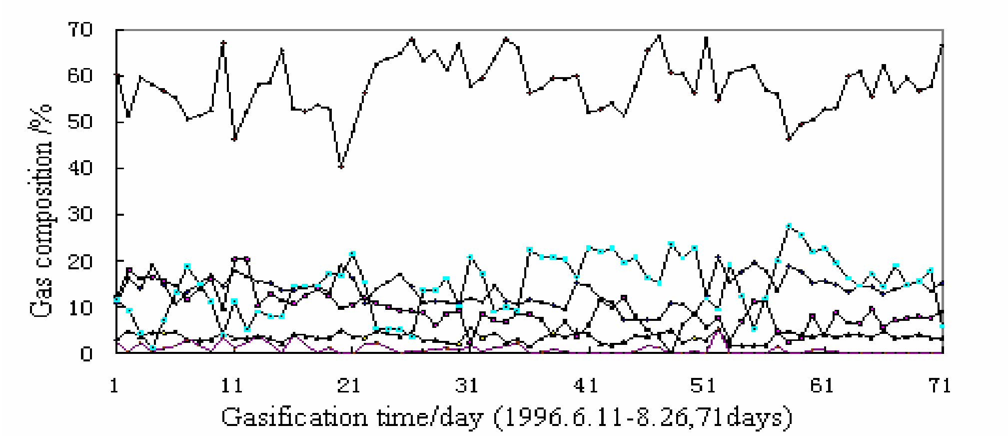

Figure 4. Gas composition of air gas

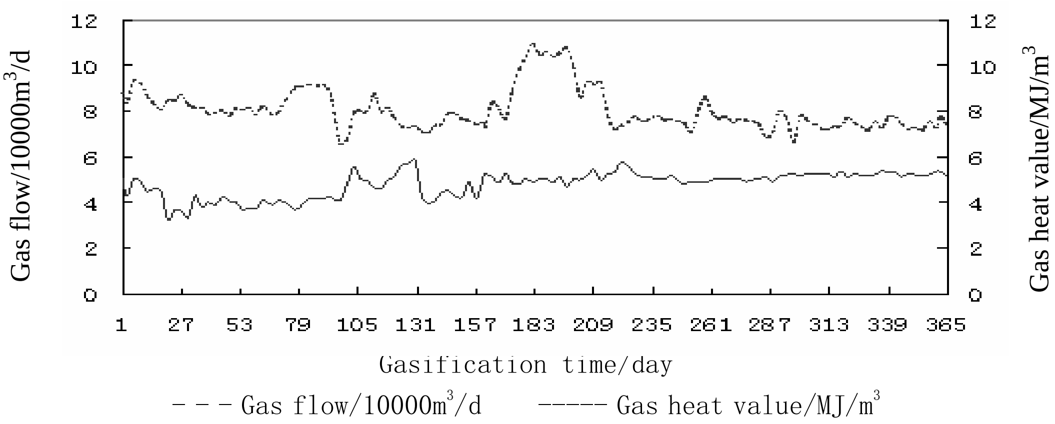

Figure 5. Heat value and flow of air gas

Table 4. Composition and heat value of #9 water gas

H_2 (%)	CO (%)	CH_4 (%)	CO_2 (%)	O_2 (%)	N_2 (%)	HV(MJ/m^3)	Flow(m^3/h)
41.46	10.39	9.12	36.68	0.00	2.35	10.22	1500
45.05	8.18	7.53	34.38	0.00	4.86	9.77	1400
46.51	9.34	9.19	32.65	0.00	2.31	10.76	1500
52.92	10.37	9.50	19.55	0.00	7.62	11.84	1200
45.32	9.13	9.24	33.10	0.00	3.21	10.60	1400

3.4 Measuring the moving velocity of the fire face

Radon (222Rn) is the only gas generating from the disintegration process of radioactive elements in nature, and it has the characteristic of moving towards the surface from underground when heated. The emanation coefficient of radon increases obviously with the increase of temperature. Thus, the radon concentration at the surface will reflect the temperature of the underground burning coal, which can be used in exploring the range of the coal combustion zone and the moving velocity of the fire face (Liang, 2002).

From Figure 6, in gasifier 9S, the first elevated radon point is 17m away from the ignition point, and the elevation extends 42m, which shows that the high temperature zone starts at 17m and the length of the zone is at least 42m including both the oxidation and reduction zones. Figure 6 shows that the high temperature zone starts at 29m, and the length of the zone is about 38m.

According to the position of the high temperature zone and the gasification time, the moving velocity of the fire face of 9S and 12S is 0.204m/d and 0.487m/d respectively.

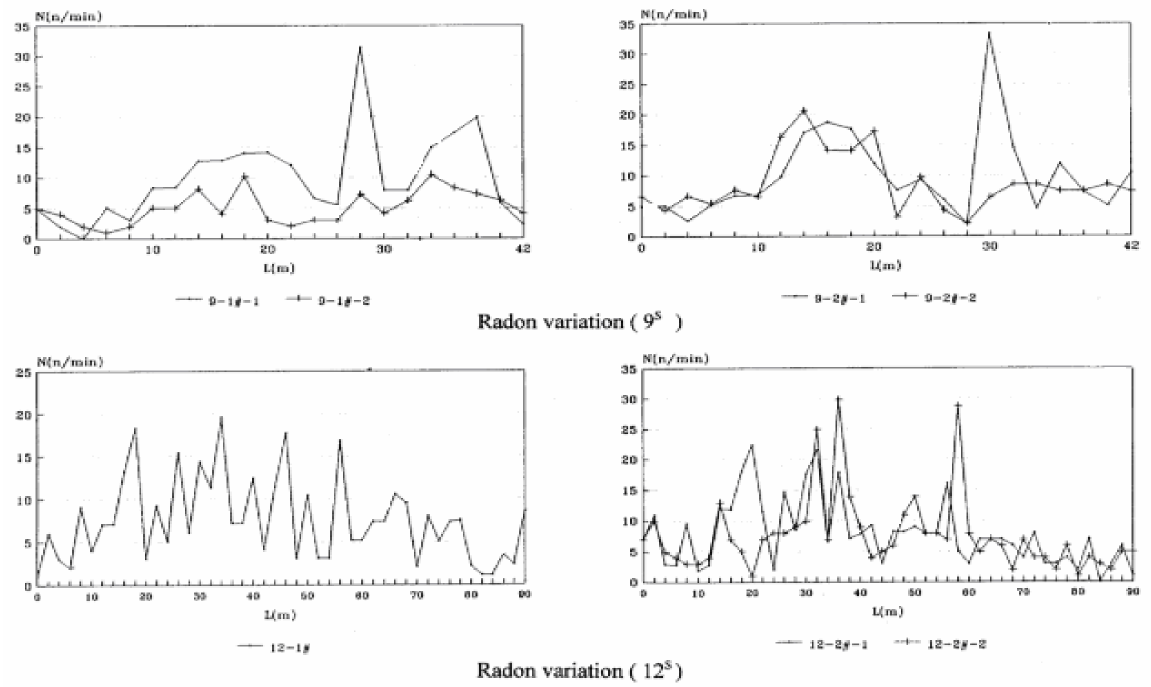

Figure 6. Changes of radon concentrations along the gasification tunnel

4 MARKET PROSPECTS FOR UCG TECHNOLOGY IN CHINA

According to the survey of China coal resources in 1997, the total amount of the discovered coal resource in China is about 10179×10^8t. The distribution of the different coal types is listed in Table 5.

Table 5. Distribution of coal types in the discovered coal resources (amount $\times 10^8$t)

Coal kind	Lignite	Lower-grade bituminous	Gas coal	Fat coal	Coking coal	Thin coal	Poor coal	Anthracite	Others
Discovered	1291.32	4320.75	1317.31	382.99	682.92	424.47	559.17	1200.16	0.27
Percent (%)	12.68	42.45	12.94	3.76	6.71	4.17	5.49	11.79	

The total amount of both the discovered and the projected coal resources with depths lower than 2000m is about 55697×10^8 t according to the geological exploring data, among which the coal resources with depths lower than 1000m take up 51.4% with an amount of 28616×10^8 t and the coal resources with depths between 1000m-2000m take up 49% with an amount of 27080×10^8t. Among the projected coal resources, the amount at depths higher than 1000m goes up to 59.5%.

As for other conditions: (1) Mining conditions: the coal suitable for opencast working is 1% of the total amount, of which lignite is 70%. (2) Mining status: thin coal seams with thickness less than 1.3m make up 8% of the total mine, while thick coal seams with thicknesses more than 3.5m are 43%. The proportion of the coal seams with obliquity more than 12° makes up 44%. (3) Safety conditions: 46% of the coal mines possess gas of more than 10 m3/ton/day.

From the above data, the amount of lignite and lower-grade bituminous makes up more than 55% of the total discovered coal resources, so it is not economical to adopt traditional mining for it. Traditional coal mining methods are only useful for coal seams lower than 1000m. Therefore, the mining of deep coal seams requires new methods. The UCG in China is sure to have a bright future for its superiority in the mining and utilization of low quality coal and deep coal resources.

5 CONCLUSION

The development of Underground Coal Gasification technology is of great importance to China and other coal-based countries. We believe the UCG technique will make major contributions to the utilization of coal resources and environmental protection through all of our efforts. Therefore, we hope to enhance cooperation with all countries that have an interest in this project to accelerate the development and application of UCG.

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