

# Practice & Probe of Underground Coal Gasification of Xinwen Mining Group Co., Ltd.

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**Abstract:** In this paper the research on the technology of underground coal gasification (UCG) and convert it into clean energy safely and efficiently are introduced. The United Nations Coal Perspective Conference in 1979 pointed 'development of UCG is the main research object for the world coal mining and the important approach to solve the technical and environmental issues existing in the traditional mining method fundamentally. Xinwen Mining Group Co., Ltd. carry out the industrial experimentation of UCG in Suncun Coal Mine. The design of the project was finished in September 1999, preparation and construction started in October and November respectively, it was ignited in March 31, 2000, air gas was produced in April 24 and water gas produced in June 9 and used to fuel the industrial boilers, supplied to 12,000 households in July 12. In November 2000, an experiment was made to generate electricity with gas. And now the gas generator in 400kw/h is running normally.

**Keywords:** probe, underground coal, gasification, gasifier

## INTRODUCTION

Xinwen Mining Group Co., Ltd. was approved by the former Ministry of Coal Industry and converted from Xinwen Mining Bureau in 1997, which was founded in 1956. By 2000, its production of ROM has added up to 300 million tons. In 1988 it became the first mining bureau to produce 100 million tons of ROM in Shandong Province and one of China's extremely large enterprises. And Xinwen Mining Group Co., Ltd. has maintained the annual output of 100 million tons for 12 consecutive years. For the moment, Xinwen mine area has a geological reserve of 828 million ton and a workable reserve of 378 million tons, among which coal below building, high ash and high sulphur coal account for over 50%, and a reserve of over 100 million tons of unworkable and abandoned coal and large coal pillar. How is these coal mined out safely and with low consumption and be fully utilized? The best method for the time being is to adopt the technology of underground coal gasification (UCG) and convert it into clean energy safely and efficiently. The United Nations Coal Perspective Conference in 1979 pointed 'development of UCG is the main research object for the world coal mining and the important approach to solve the technical and environmental issues existing in the traditional mining method fundamentally.

### 1. PRACTICE OF UCG IN XINWEN MINING GROUP CO., LTD.

In 1999, Xinwen Mining Group Co. in cooperation with China University of Mining and Technology (Beijing School) and Shandong Coal Mine Jinan Design and Research Institute set up the research group. On the basis of study and argumentation, it was decided to

carry out the industrial experimentation of UCG in Suncun Coal Mine that is 100 years old. The design of the project was finished in September 1999, preparation and construction started in October and November respectively, it was ignited in March 31, 2000, air gas was produced in April 24 and water gas produced in June 9 and used to fuel the industrial boilers, supplied to 12,000 households in July 12. In November 2000, an experiment was made to generate electricity with gas. And now the gas generator in 400kw/h is running normally.

In September 8 2000, 'Project of Technology of Suncun Coal Mine UCG and Its Utilization' passed the technical appraisal sponsored by Shandong Province Science and Technology Committee. The experts from State ministries and committees, relative universities and scientific and research institutes spoke highly of the project and held unanimously that the depth, systematization and standardization of Suncun coal mine's UCG technology research and utilization in the industrial experiments has made a breakthrough, it is a successful model project of industrialization from gas production to utilization, and has reached the world's leading level and has broad future to spread and utilize.

### 2. SUNCUN COAL MINE UCG ENGINEERING OF XINWEN MINING GROUP CO., LTD.

2.1 UCG is a combustible gas-producing process achieved through a thermo-chemical reaction with the coal burnt under control deep in the earth, and among which three important technologies like mine construction, coal mining and coal gasification are integrated to realize coal gas production without anybody, mining equipment in mine and gasification equipment on the ground. It is a new high technology

acquired with the efforts of multi-branches of learning to develop clean energy resources and chemical industrial materials, changing a physical mining into a chemical one. Suncun underground coal gasification engineering is arranged in the abandoned leftover bits & pieces of coal at -50m level. The design is required to drive a tunnel in the coal face, two ends of which are connected with two drilling holes from ground respectively, and one is used for intaking air while another for returning air, after the coal face is sealed up and ignited the underground coal gas will be obtained in the air-returning hole by such technological measures as effective control of air volume and so forth, and after being purified through a series of technologies like water spraying, drop collecting, tar collecting, desulphur and etc. it can be delivered to the consumers through conduit grid.

## 2.2 UCG mainly consists of four parts

- 1) Underground gasifier: consists of three parts, air current thoroughfares, gasification tunnel and drilling holes.
- 2) Monitoring & control system: to monitor and control underground gasifier & ground equipments (temperature, pressure, flow, ingredient) automatically.
- 3) Purification system: consists of washing tower, drop collector, coke collector and desulphur equipments.
- 4) Store & convey system: consists of gas-storing cabinet, main pipes, branch conduit grid and etc.

During the proceeding of the engineering, the group staff with no precedent examples to rely on pooled wisdoms and brave risks to construct while amending the relevant design, not only its installation, adjustment and operation were fulfilled on time but also it is ignited successfully at one time, and in the meantime several self-innovated projects were made and confirmed by the relative experts. For example, I. The gasification experiment succeeded for the first time nationwide in moderate inclined coal seam with a thickness of less than 2m. II. Pollution is eradicated and the waste water is fully utilized by enabling purified water to return to the gasifier to produce water coal gas. III. The technology has been invented to produce underground water coal gas through two pulsation phases. IV. The technology has been invented to use self-heat of the gasifier and the steam from water sprayed to produce water coal gas. V. The technological problems of pipes' expanding with heat & contracting with cold has been overcome by adopting such a compensation method fixing the tops while enabling the ends to extent or shrink freely. To sum up, the stability and the safety of the production system are guaranteed through implementing the created technological projects mentioned above.

## 2.3 The benefits

Based upon the successful experiment on Suncun Coal Mine UCG, outstanding benefits have been achieved as follow:

- 1) Economic benefits: the experiment attests that each ton of coal can produce 3000 m<sup>3</sup> of coal gas, the cost of Suncun underground coal gas is RMB yuan 0.19/m<sup>3</sup> while the market price is RMB yuan 0.5/m<sup>3</sup>, annual profit is RMB yuan 3.39 million and payoff period is 3.8 years.
- 2) Social benefits: conditions to utilize the coal resources below buildings have been created, subsidence of the earth's surface can be eliminated while compensation on the ground being reduced and therefore the problem resulted from mining below "three bodies" (building, water and railroad) has been solved, the coal resources can be fully utilized.
- 3) Environmental protection benefits: A new method to utilize the high ash coal & high sulphur coal has been found. The abandoned coal pillars and leftover bits & pieces of coal can be used for gasification, particularly the gas produced from high ash coal & high sulphur coal can be changed into clean energy resources while being purified. Besides, the gas from gasifier will be changed into clean one through a series of procedures like spraying, dewatering, tar eradicating, desulphur and purifying, eliminating its pollution of the atmosphere. Moreover, the waste residue is left in the gasifier through underground coal gasification, so it does no contamination to the ground, in the meanwhile the waste water from washing tower and electric tar-collector can go down to the underground gasifier to be turned into steam so it can't result in any pollution.

## 3. DEVELOPMENT OF UCG IN XINWEN MINING GROUP CO.,LTD.

Upon the experience & lessons of Suncun UCG Station construction, the Group Co. designed and constructed Xiezhuang Gasification Station in Oct.10, 2000. The gasifier's shape, monitoring measures, purifying technology and etc. had been improved, it was completed in Mar.3, 2001, ignited on Apr.8 and began to supply 6000 households with gas, and with a calorific value of 8.36~13.79kJ/Nm<sup>3</sup> it had produced 9.8 million m<sup>3</sup> continuously by the end of Dec., 2001. Now Erzhuang Gasification Station and Zhangzhuang Gasification Station are under construction with the guide of the Group Co.. Up to now the second phase engineering designs of Suncun & Xiezhuang Gasification Stations have been completed, and they will be constructed in Jan. 2002. Xie zhuang UCG is planned to provide gas for the residents of Xiezhuang and Liangzhuang while Erzhuang UCG for the residents of Laiwu City & Erzhuang and besides, its surplus gas will be provided for Zhaofeng Pottery Factory nearby & the newly constructed Gas Power Plant with a capacity of 6000kW, using underground coal gas to generate electricity, promoting the economic benefits. Zhangzhuang gasification Station is planned to launch a technological research of coal chemical industry, utilizing underground coal gas to extract hydrogen, produce methanol, dimethyl ether and etc., so the production technology & its application scope of UCG will be improved and

broaden.

#### 4. SOME TECHNOLOGICAL ISSUES

Although many problems have been worked out through two years of practice, it is a kind of revolution to change a physical mining into a chemical one, meanwhile it is also a big transformation, its technological maturity is not so much as that of usual physical coal mining because it has been less than 10 years since the semi-industrial experiment, the engineers & administrators are exploring and making summary on it while trying to perfect it, so there inevitably exist some questions ahead.

4.1 Issues of the gas calorific value & the gas volume produced by single gasifier

##### 4.1.1 Calorific values of underground coal gas

The calorific value of the underground coal gas up to 8.36-13.79kJ/Nm<sup>3</sup> is satisfactory, it is the same as or a little higher than that of two-section gasifier on the ground by comparison. Other underground coal gas calorific values except those of America and Russia that use rich oxygen & steam as catalysts in the underground gasification station to produce coal gas have not surpassed 8.36kJ/Nm<sup>3</sup>.

##### 4.1.2 Ingredients of the underground coal gas

With regards to the gas ingredients, H<sub>2</sub> content of the gas from underground gasifier is the same as or a little higher than that of the gas from the two-section gasifier on the ground by comparison, both CH<sub>4</sub> content & CO<sub>2</sub> content are much higher than that of the gas from the two-section gasifier, but CO content is much lower than that of the gas from the two-section gasifier on the ground.

##### 4.1.3 Single gasifier production of gas

The production of gas by single gasifier is not ideal. At present the volume of gas produced by on gasifier is about 15000m<sup>3</sup>/d doesn't reach the requirement of the large scale industrial utilization.

##### 4.1.4 Elements influencing the single gasifier production

There are a lot of elements influencing the single gasifier production. Such elements as thickness of coal seam, coal quality, air permeability of seam, water content of the seam, dip of the seam, type of gasifier, gasifying agent and so on have certain influence on the underground gas production volume.

##### 4.1.5 How to increase the single gasifier production volume

Based on study and practice, the main measures to be taken are as follow:

- 1) Direct and reversal air blast, increase the length of oxidization zone and the temperature inside

the gasifier and enhance the energy accumulating capacity of the gasifier.

- 2) Rich oxygen gasification, balance the heat emission and producing gas, absorbing heat inside the gasifier to realize the continuous production of gas.

#### 4.2 Monitor and control the underground gasifier

To monitor and control the underground gasifier effectively is the key to the development and improvement of the UCG technology.

##### 4.2.1 Monitoring of the underground gasifier

Monitoring is the 'eye' of people to observe the underground gasifier, basis to control the underground gasifier and foundation to check the control results. Without necessary and reliable monitoring, without knowing the running of the underground gasifier, no control will be exerted.

- 1) monitor the volume of the air intake and return: proper flow meter has to be used to increase the accuracy for analysis.
- 2) Monitor pressure: pressure inside the gasifier is monitored to reach the rational working conditions.
- 3) Monitor the ingredients of gas: automatic chromatograph is used to monitor to satisfy the requirement of precision.

##### 4.2.2 Control of the underground gasifier

Through the observation of the parameters (temperature, pressure, flow) of underground gasifier, current working conditions of the gasifier can be analyzed to adjust the air intake volume, steam (water) flow volume to enable the underground gasifier produce the good gas.

##### 4.2.3 Treat the parameters monitored

Production of the underground gasifier is continuous. It is difficult for man to sum up, analyze the original parameters (temperature, pressure, flow) monitored and then to instruct and control with the information feedback. Necessary computer software has to be developed to sum up and analyze the monitored parameters and instruct people to control and further realize the automatic monitoring.

#### 5. SOME OPINIONS ABOUT THE UCG

5.1 UCG has development future in the aspects: to solve the issue of pollution by high sulphur coal, to emancipate the coal reserves below 'three bodies' and coal pillar and to produce clean energy. But why has it not been developed over tens of years? On the one hand, mining of oil and natural gas has developed quickly, and they have some advantage in terms of mining, transporting, storing and utilization and they have low cost and high calorific value. So the urgency to develop the UCG technology has not been strong. Over recent years, the price of oil and natural gas has gone up quickly. China has become a country of net

import of crude oil. For energy safety of China, people have come to pay importance to the production of the clean energy with the rich coal reserves.

5.2 UCG technology and its application in China are very young and there is still room for improvement. In 1960s the former Soviet pointed 6 problems when they summed up the UCG: 1) difficult to monitor and control, 2) serious leakage (19%), 3) atmosphere and water pollution, 4) low efficiency of the energy utilization, 5) high cost ( compared with natural gas ), 6) low production (compared with natural gas ). According to our practice, we have found no leakage, no pollution of atmosphere and water. The other problems are not serious. But difficulty in monitor and control and low production have emerged gradually.

5.3 In terms of the application of underground gas, First its utilization in households is simple and relative mature and its economic benefits are considerable. Second when it is utilized to fuel the industrial boilers, compared with burning the coal, the price of the gas is difficult to raise. Third it can be used to generate electricity in three ways: 1) electricity generation with steam: to fuel the steam boiler to generate electricity with steam. It will require low gas ingredients and cleaning grade but its efficiency is the lowest (about

25%). 2) electricity generation with internal combustion engine: to drive the internal combustion engine with gas to generate electricity. It requires high cleaning of the gas. 3) combined electricity generation with gas steam turbine: first use gas to drive the gas steam turbine to generate electricity, its residual heat burns the steam boiler to generate again. Its efficiency is highest (45%). But it require better cleaning treatment of the gas to extend the life of steam turbine. Fourth it can be used as chemical raw materials to produce methanol, DME...and to extract  $H_2$ ,  $CO_2$ ,  $CO$  and so on. To apply the gas in chemical industry is an option that is high in input, risk and benefit. And there is strict requirements for useful contents of gas ingredients and their percentage, for high cleaning grade. And it also requires the stable production.

The industrial experiment of UCG has succeeded. However there still exist problems when we use the gas produced underground to meet the requirements of large scale production and of chemical raw gas. And this is to be studied and improved further.

5.4 When the coal is gasified underground in a existing mine, the gasifiers are connected with the mine and the gas must be prohibited from getting into the mine. So it must be obturated and cut off.