Technical path analysis of clean and efficient utilization of coal in Shajingzi mining area

Lan Yu1*, Qingfeng Yang2, Ning Sun1, Shuang Li1, Qiang Jia1, Jiyuan Xiao1, Heng Zhang1

1 Engineering College, LongDong University, Qingyang, 745000, China
2 Gansu Energy Chemical Industry Investment Group, Lanzhou, Gansu, 730000, China
3Corresponding author’s e-mail:418187657@qq.com

Abstract. In Shajingzi mining area, the coal quality is very low, and many questions will be faced in the process of exploding the area. First, the author analyzed problems in resource development and utilization, and proposed the paths of clean and efficient utilization of coal, which are clean coal power generation technology (including SC, USC and near zero emission power generation technology), CHP energy saving and emission reduction technology, technical analysis of classification and quality utilization and coal transportation technology by pipeline. The author also analyzed the main characteristics in detail, which are high volatile content, high tar content, rich oil coal-high oil coal, and an ideal raw material for low temperature carbonization, tar hydro treating, semi coke gasification and CO combustion power generation. The author also summaries the advantages and disadvantages of coal transportation technology by pipeline, which is a new and efficient way of utilization. Finally, according to the development strategy of "clean, step-by-step, timely and comprehensive", the author proposes the comprehensive industrial chain of coal, electricity and chemical industry will be the best path.

1. Introduction
The Shajingzi mining is affiliated to Huanxian, Qingyang City, Gansu Province in the eastern part of Gansu Province. It is an important supporting area in Longdong National Energy and Chemical Industry Base and is also the new growth level in Gansu coal industry in the future. There are a lot of coal resources buried underground. Four coal mines are exploded in the mining area: Liuyuanzi coal mine, Mafuchuan coal mine, Maojiachuan coal mine and Qianyangshan coal mine in the west, with a total annual output of 16.9 million tons. In May 2015, the National Energy Administration issued the “Coal Clean and Efficient Use Action Plan (2015-2020)” document, which puts more stringent requirements on coal production, processing and utilization of coal. It is a problem faced in the planning of new coal production bases in China of how to change the way of coal consumption and clean and efficient utilization. According to detailed results of geological exploration, the buried coal resources which are long flame coal and the lower calorific value, insufficient power used as fuel and the higher volatile content. There will be a lot of smoke and dust, as well as carbon monoxide, carbon dioxide, sulfur dioxide, nitrogen oxides, organic compounds and other pollutants if the kind of coal is directly combusted and utilized, and a series of environmental problems will be caused. People can take advantage and avoid the disadvantages by reasonable clean and efficient transformation coal technology. It is not only solving the problems of environmental protection and low efficiency of
energy transformation, but also is an important significance for improving the economic benefits of the mining area.

2. Problems in resource development and utilization in Shajingzi mining area

There are rich coal resources in Shajingzi mining coal area, but in the north is the Shenhua coal production base with huge output, similar coal quality—mainly low-level long subsidence coal. In the south there is a Binchang mining area with better coal quality—mainly weak coal and non-stick coal. In the east there is Shanbei coal mining area. At present, the Xiying railway is passenger transport under construction, so it is unrealistic for coal to flow north-south. It is only by automobile transportation, the cost is high, and the products obviously do not have market competitiveness. There are mountains in the east, which will be transported, only the Huanxian-Guyuan Zhujiawan Railway is planned to be a freight line in the west. The Huanxian-Chujiawan railway is a total length of 122.9 kilometers, including 82.6 kilometers in Gansu Province, with a design speed of 120 kilometers per hour. Later, it will transport coal from the entire Shajingzi mining area, and the railway transportation capacity is obviously insufficient.

Due to the weak industrial foundation of Qingyang, the development of coal resources as well as coal industrial is lagging behind. As a result, the potential of coal processing and utilization is also insufficient. In recent years, people has faced a severe situation of coal mine efficiency decline, in which the new challenges has been brought in Qingyang industrial plan. In recent years, the smog that frequently bursts into the table has warned us that the environmental capacity on which the survival depends has reached the limit, and the conversion of coal to control the pollution caused by coal utilization will become the main direction of innovation and development[1]. Therefore, the Shajingzi mining industry must focus on national planning, effectively solve the water resources dilemma, and consider the comprehensive utilization of coal, electricity, chemical, metallurgical and timber industrial chains, and make full use of advanced technologies such as coal power technology, coal multi generation, modern coal chemical industry and other advanced technologies. The favourable conditions will be created for the development of coal, and a good momentum of coordinated development will be finally achieved in various regions in this province.

All in all, there are the following problems in resource development and utilization: (1) the industrial base is backward and the talent pool is insufficient. (2) located in arid areas, lacking water resources; (3) poor infrastructure and poor construction conditions; (3) backward transportation facilities and limited road transportation capacity.

3. Path analysis of clean and efficient utilization of coal

Clean power generation technology and classified utilization of coal are the mainstream of the development of coal power industry in the future. It is based on the proposed development strategy of "clean, step-by-step, timely and comprehensive" in Shajingzi mining area. Taking the way of gradual development and rolling development, the enterprise should develop clean coal power industry and pay close attention to the development trend of coal chemical industry. When the technology is mature and the benefits of chemical products are stable, a comprehensive industrial chain of coal, electricity and chemical industry will be formed. Therefore, the following development technology path is proposed.

3.1 Analysis of clean coal power generation technology

Today, People promote vigorously the clean development of coal-fired power generation and fully apply advanced coal-fired power generation technology, which not only meets the local basic power demand, and ensures the safe and stable operation of the power grid, but also reduces ecological damage and environmental pollution, and forms the development of environmental protection.

In order to realize the above-mentioned development mode transformation, the key lies in the rapid development and industrialization of large capacity, high efficiency, low pollution and low water consumption advanced coal-fired power generation technology. Based with the existing technical
conditions, supercritical and ultra supercritical pressure units are one of the most important trends in the development of thermal power in the world, which is the most effective way to improve the efficiency of coal-fired power and reduce the pollutant emissions per unit of power generation at this stage. The supercritical pressure unit (SC) has been widely studied and applied in developed countries. Based on the supercritical technology, ultra supercritical (USC) thermal power generation technology is developed through further improving the main steam temperature or pressure level to continuously improve the power generation efficiency and the corresponding energy conservation and environmental protection level. The unit capacity of ultra supercritical unit can reach $1 \times 10^6$ kw, the coal consumption of critical unit is reduced by 14%, and the land use area is basically the same as that of sub critical unit. In addition, due to the large increasing of single unit capacity, the investment in energy conservation and environmental protection for each kilowatt of power generation capacity is greatly reduced under the condition when the investment increases little in single unit of flue gas purification device[2].

The 4 units "near zero emission" transformation project has been completed and checked before acceptance in December 2015 in Shenhua group Guohua Sanhe Power Plant Coal Power. The project applies integrated multiple technologies such as installing low-temperature economizer. In addition, the technology combination mode of gradual and deep purification of single pollutant and removal of other pollutants shall be considered. It has achieved the strengthening effect of low-temperature dedusting, SO$_3$ adsorption, desulfurization and integration dedusting technology. The tail net flue gas led to the existing flue gas tower is discharged by the long-distance FRP flue, so as to realize the integration of the whole plant's flue gas tower. The plant developed a flexible plate wet electrostatic precipitator technology with independent intellectual property rights of Shenhua. After transformation, the dust emission of the whole plant is $\leq 3$ mg / Nm$^3$, SO$_2$ $\leq 25$ mg / Nm$^3$, NO$_x$ $\leq 38$ mg / Nm$^3$. The project plays a leading role in clean and efficient power generation of coal-fired power station and has a high reference value for development of coal-fired power in Qingyang.

3.2 Analysis of CHP energy saving and emission reduction technology

CHP is an advanced form of energy utilization that produces both electricity and heat. After burning coal in general thermal power plants, only one kind of product is electricity. In the process of power generation, a lot of heat energy is taken away by circulating water and discharged into the atmosphere. The energy utilization rate of thermal power plant is only about 35%. In the process of power generation, the thermal power plant transmits part of the thermal energy to thousands of households through the thermal pipeline, so it burns the same quantity and quality of coal. The thermal power plant can not only provide electric energy, but also provide steam for industrial production and hot water for residential heating. Thermal efficiency of thermal power plants is generally more than 45%. In addition, due to the large boiler capacity, good dust removal effect and high chimney, desulfurization and denitrification it can be also achieved in the thermal power plant in the furnace. Compared with small boilers and thermal power plants, its environmental and social benefits are very huge.

The working principle figure is shown in Figure 1. The efficiency of CHP is much higher than that of CHP. In general, and the power generation efficiency and heating efficiency can be increased by 10% - 20% and 20%-30% , respectively. CHP is an energy-saving method recognized by the world. Based on the principle of energy cascade utilization, it produces the electric energy and thermal energy needed by people, which can effectively save energy, improve environmental quality, and greatly improve the energy utilization rate. Therefore, all countries are actively promoting and adopting cogeneration technology[3].
3.3 Technical analysis of classification and quality utilization of coal

Since 2004, the concept of high-efficient transformation of low-grade coal into multi generation has been put forward based on its characteristics in Shaanxi coal chemical industry group Co., Ltd. The core of the concept is low-grade coal pyrolysis technology, which is optimized by coupling and integration of four-grade coal transformation technology. Seeing Figure 2 for its technical roadmap.

After years of research and practice, a number of industrial demonstration devices have been built and a series of technical results have been achieved in Binchang mining area, Huangling mining area, Shenhua Baotou, Yulin area and other places. At present, in the low-level coal quality and high-efficiency transformation multi generation system the group has carried out upgrading research and development and process optimization of 7 key technologies based on the platform of "National Key Laboratory for clean transformation of energy and coal quality" and the technology support of "production, learning and research" led by enterprises.

In addition, CAS put forward a clean and efficient step utilization solution of low rank coal according to the composition and structural characteristics of low rank coal. The technology is achieved by extracting the existing oil and gas resources in the coal, burning the remaining semi coke for power generation, or converting it into liquid fuel and chemicals through gasification. Three technical routes have been formed: "pyrolysis-oil and gas upgrading-semicoke combustion-power
generation”, "pyrolysis-gasification - synthesis" and "pyrolysis-gasification-Fischer Tropsch synthesis-Oil Co treatment”.

Three technical routes have been formed: "pyrolysis-oil and gas upgrading-semicoke combustion-power generation", "pyrolysis-gasification - synthesis" and "pyrolysis-gasification-Fischer Tropsch synthesis-Oil Co treatment". The technology system of comprehensive utilization of low rank coal with high energy efficiency, low pollution, low emission and high value, which is suitable for the characteristics of China's resources, has greatly promoted the technological progress of China's coal power and coal chemical industry.

The main characteristics are high volatile content and high tar content in Shajingzi area. Most of the coal seam tar yield is more than 7%. It belongs to rich oil coal - high oil coal the oil. It is an ideal raw material for low temperature carbonization, tar hydrotreating, semi coke gasification or CO combustion power generation. If the coal products in the mining area are only used for thermal power generation, they cannot be fully utilized. If the oil and gas in the coal are extracted from the cleaned coal in the mining area through coal pyrolysis, then the clean fuel such as Lancel, oil, LNG and other energy products can be obtained and processed, including sewage, waste gas, coal gangue and so on, can realize the classified utilization of coal quality[4].

3.4 Technical analysis of coal transportation by pipeline
Pipeline coal transportation is based on water, and the washed raw coal is crushed into fine particles, mixed with water to form a certain concentration of coal water slurry, and the coal water slurry is pressed into the pipeline through a self-flowing or high-pressure pump, and the coal slurry reaches the terminal. It is then treated by dehydration. The process of pipeline coal transportation is shown in Figure 3.

![Figure 3 Pipeline coal flow chart](image)

Pipeline coal transportation is generally long-distance transportation. It is necessary to make full use of the difference between the starting point and the end point, reasonably arrange the pipeline and the pressurized pumping station, correctly calculate the pressure of the pumping station, and fully consider the pipe diameter, toughness, strength, anti-wear and anti-wear. Corrosion and other aspects are required to ensure the stability of the system.

In November 2019, the Shenwei pipeline coal transportation project, the first independent demonstration project was completed in China. The project started construction in 2011 by Shaanxi Coal Chemical Industry Group. The pipeline starts from Shenmu Hongliulin Coal Mine in Yulin City, Shaanxi Province, and ends at Pucheng County Coal Chemical Industry Park in Weinan City, Shaanxi Province. It plans to transport 10 million tons of coal per year. It has an annual water consumption of about 9 million tons and an annual working time of 7,920 hours. It delivers a high concentration of coal water slurry. The terminal coal water slurry plan is 3 million tons for chemical coal, which is sent to the Pucheng coal-to-olefin plant. Another 400 tons of coal is dehydrated and transferred to other users as power coal. The remaining part was sent to Huaxian Industrial Park and High-tech Industrial Development Zone in the south of the city for supply of downstream acetic acid, acetic anhydride, methanol and fertilizer. It is estimated that the transportation cost of coal is 88 RMB per ton, which is 0.12 RMB/ton. km after conversion. After the project is completed, it can realize the supply of downstream power plants, chemical plants and thermal coal, which reduces the construction cost of downstream projects and has significant benefits.

If we learn from this idea. we plans a coal transportation pipeline from the Shajingzi mining area in northern Qingyang to Baiyin. The raw coal mined in the Tiansha mining area is treated with clean coal in the pulping plant and converted into coal water slurry. Then coal water slurry will be transported to Liuchuan Industrial Park and Baiyin High-tech Development Zone. The method can realize integrated utilization of upstream and downstream.(1) To achieve the complementary advantages of resources
formed by the two cities of Baiyin and Qingyang. (2) Adequate natural height difference advantages of raw coal and user geographical location. (3) Enhance the competitive advantage of low-quality coal products in Shajingzi. (4) The water delivery function of the pipeline can become a strategic drought-resistance reserve along the road and improve the resilience of the pipeline passing area. Both Xihaigou and Huanxian are arid areas. The construction of this pipeline can save water and relieve drought in the face of extreme drought. (5) The technical, economic and environmental protection advantages are obvious [5].

4. Concluding remarks
Due to the low quality of coal and the limited capacity of the surrounding market, in Shajingzi mining area it is necessary to scientifically study and judge the local coal types, resources in order to transform the resource advantages into economic advantages. After selecting the efficient transformation path and reasonable SWOT analysis method, the way of green mining and clean utilization of coal will be selected based on the development strategy of "clean, step-by-step, timely and comprehensive". It is necessary to solve the problem of water shortage, create favourable conditions, gradually develop and roll forward, and pay close attention to the development trend of coal chemical industry. When the technology is mature and the benefits of chemical products are stable, a comprehensive industrial chain of coal, electricity and chemical industry will be formed, I think several methods put forward are worth further consideration and exploration in the text[6].

KNOWLEDGEMENTS
Fund projects: 2018 work safety scientific research projects of Gansu Province (GAJ00017), , Gansu Province industrial green low carbon transformation and upgrading projects (ggld-2019-029), (ggld-2019-060), (ggld-2019-038)

References
[1] Dai Shengfu, Li Yongfeng. (2015) Development strategy of coal enterprises under the new normal of China's economy. Energy technology and management., 40: 190-193.
[2] Liu Kuan, Shi Yongkui. (2013) Research on the development route of efficient and clean coal-fired power generation., Coal, 22: 9-12.
[3] Shao Youyuan, Xiaao Hanmin, Qin Frank G.F., Discussion on Performance Evaluation Method of Distributed Combined Cooling, Heating, and Power System. Journal of Thermal Science., 6:112-120
[4] Li Shuai. (2017) Case study on classification and quality utilization of Shaanxi coal. Energy., 12: 74-75
[5] Han Bing. (2014) Current situation of coal transportation by pipeline and feasibility analysis of coal transportation by pipeline in Heishan coal mine., Coal economy research., 30:74-76
[6] Zhang Xiaoming, Yang Shifan. (2014) Selection and feasibility of coal utilization direction in Shajingzi mining area. China Academic Journal electric publishing house, 6:17-18