

COOPERATION BETWEEN CONSTRUCTION OF JINTAN GAS STORAGE CAVERN AND LOCAL SALT INDUSTRY

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Abstract: West-East Gas Pipeline is the first modernized natural gas pipeline in China with large diameters, long distances and high pressures. In order to ensure supplies during seasonal peaking, and to provide safe operation, it is necessary to construct a large-scale underground gas storage facility in East China. According to a comprehensive geologic evaluation, Jintan salt basin has been chosen as the first gas storage facility location.

West-East Gas Pipeline Company Petrochina started Jintan Gas Storage Project in 2000, and has been cooperating with China Salt Jintan Co., Ltd. on the following aspects of the project:

1. The research, design, and construction phases of the project.
2. Conversion of brine well cavity to gas storage cavern.
2. Salt cavern design and new leaching.
3. Supply natural gas to Jintan City.
4. Other miscellaneous issues and problem solving.

Key words: salt cavern, gas storage, salt industry, cooperation

PREFACE

West-East Gas Pipeline starts from Tarim Basin in West China, east to China's largest commercial city-Shanghai, with a total length of 4,000 kilometers and the annual gas transmission capacity of more than 10 billion cubic meters. It is China's first large diameters, long-distances, high-pressures modern natural gas pipeline. In order to ensure the seasonal peak-modulating and safe operation of the pipeline, it is necessary to construct a large underground gas storage cavern in East China to guarantee the safe and stable gas supply for the residents and industries in Yangtze River Delta region.

Jintan Salt Basin is located in the economically developed Yangtze River Delta region. It is near Shanghai in the east, and near Nanjing in the west. It has convenient transportation of freeway, railway, waterway and civil aviation. The basin is rich in rock salt resources and has salt-containing area of 60.5m^2 , with burial depth of around 1,000m, reserve of 16.242 billion tons, and NaCl content of 12.538 billion tons, which is the best large-scale salt mine in East of China. Due to its favorable geographical location and geological conditions, it is the ideal position to construct underground gas storage cavern for West-East Gas Pipeline.

Since 2000, West-East Gas Pipeline Company PetroChina (hereinafter referred as West-East Gas Pipeline Company) has been cooperating with local salt industry, China Salt Jintan Co., Ltd. (hereinafter referred as CSJT) to make feasibility study for Jintan Salt Basin to construct underground gas storage cavern, identifying the cavern construction area and demonstrating the necessity of building vacuum salt plant in Jintan and accelerating the development of local salt industry according to the characteristic that a large amount of brine will be produced during the construction of gas storage cavern. The two parties made extensive cooperation in the aspects of conversion of brine well cavity, construction of gas storage cavern, digestion and handling of brine, construction of vacuum salt plant and natural gas supply, etc., gaining mutual benefits and collaborative developments.

1. Cooperation Of Research And Design In The Early Stage

In 2000, with the development of West-East Gas Pipeline Project, in order to accelerate the construction of underground gas storage cavern, West-East Gas Pipeline Company started the investigation and research work of site selecting for gas storage around Yangtze River Delta region, where is the major natural gas consuming market. Jintan Salt Basin is the main area of the investigation.

Jintan Salt Basin was discovered in 1960s, and the development and utilization was started in late 1980's. In 1988, Jintan Salt Development Corporation was established, and at the same year in June, it made a joint investment with East China Petroleum Geology Bureau to set up Maoxing Salt Mine. In October 1988, the first brine well Mao 1 was put into production. By 2000, there were seven salt mines, and more than thirty Brine wells in Jintan Salt Basin. The annual production of brine is around one million tons, mostly were sold to Chlorin-Alkali enterprises in the regions of Jiangsu, Zhejiang and Shanghai.

In order to match the investigation and research of underground gas storage project in Jintan Salt Basin, speed up the early progress of the project, promote comprehensive utilization of Jintan rock salt resources, and accelerate the regional economic development. Since 2000, Jintan City increased the investment and management of the local salt industry. In 2001, China National Salt Industry Corporation, Jiangsu Salt Industry Group, Jintan Salt Chemical Industry Corporation jointly established CSJT, carrying out mergers and acquisitions of small salt mines. Unified planning, operation and management were implemented to improve the producing management of salt mine. In the feasibility study and evaluation process of West-East Gas Pipeline Company for the underground gas storage cavern, CSJT provided detailed and reliable geological, drilling, logging, mining data as well as a great deal of material data, i.e. rock core, introducing their brine digesting and treating ability. The company gave the all-round support to West-East Gas Pipeline Company to carry out exploring well drilling and 3D seismic construction.

2. COOPERATION OF CONVERSION OF BRINE WELL CAVITY TO GAS STORAGE CAVERN

After West-East Gas Pipeline Company determined to construct underground gas storage cavern in Jintan Salt Basin and identified the cavern construction area, in order to obtain the first set of salt caverns as soon as possible and to supply the emergency gas for the safe operation of West-East Gas Pipeline, the Company began to explore the possibility of conversing the brine well cavity to gas storage cavern.

Before the start of the modification project, after more than ten years' brine producing, forty more brine well cavities had been formed. For sonar measurement of salt cavern shape has never been done in the mining process, West-East Gas Pipeline Company made pre-selection of forty more brine well cavities before sonar measurement. During the process of pre-selection, CSJT provided the production data for each brine well and made detailed introduction to the producing process, finally West-East Gas Pipeline Company selected fifteen brine well cavities to make sonar measurement and evaluation of cavern shape.

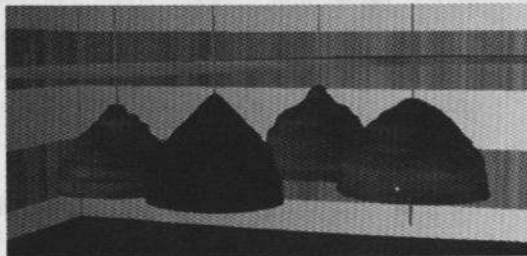


Figure 1: four caverns

3. COOPERATION IN CONSTRUCTION OF GAS STORAGE CAVERN

In January 2005, in order to explore the construction technique and technology of underground gas storage cavern in Jintan, West-East Gas Pipeline Company made use of JZ-1 well to begin pilot test of cavern construction, completed the fourteen new wells' drilling and construction of water-injection station at the end of 2006, and

Most of the fifteen brine well cavities are CSJT's production wells. During the in-site construction of sonar measurement and the subsequent conversion of the brine wells, the two parties worked together closely. West-East Gas Pipeline Company reasonably arranged the construction periods and processes, completing the conversion of six brine well cavities on the premise with minimum impact on CSJT'S normal production of brine. Moreover, CSJT overcame the difficulties of declining output of brine, gradually phased out the brine production for eight wells.

In September 2007, the completion of the last well's gas injection and brine discharge marked that the conversion of brine well cavity to gas storage cavern has succeeded, forming the natural gas storage capacity of 110 million cubic meters, emergency gas supply of 50 million cubic meters, peak regulating and gas production of 30 million cubic meters. until now seven-round gas injection, six-round gas production has been carried out, playing a significant role in the course of the summer peak and valve repair in the upstream of the pipeline, at present the pressure of each well cavity keeps stable, the operating parameters are normal, playing out the advantage of underground gas storage.

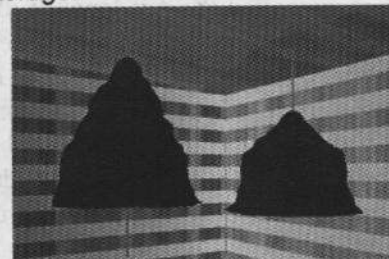


Figure 2: two caverns

started the construction of large-scale salt cavern.

In the construction of gas storage cavern, after several rounds of negotiations, West-East Gas Pipeline Company and CSJT decided to rely on Jintan Salt Basin and make use of resources advantages of both parties, promoting the cavern construction and accelerating the development of local salt enterprises from the perspective of strategic cooperation. The two parties signed a cooperation agreement, that is, brine produced in the construction of gas

storage cavern will be supplied to CSJT according to certain standard and CSJT undertakes the task of fresh water supply and brine digestion. This strategic cooperation not only solved the problem of the treatment of the brine produced in the process of cavern construction, but also provided raw material for the local salt industry. It had great significance for the steady implementation of the integration of the resources and industries in Jintan Salt Basin, promoting the extension and expand of salt chemical industry chains, improving the sustainable development capacity for Jintan Salt Basin, and adjusting and optimizing the regional economic structure.

In the past few years' cooperation between the two parties, West-East Gas Pipeline Company overcome many difficulties for the first time to construct salt cavern and brine production, ensuring the brine supply can meet the requirement of CSJT's brine sale and 600,000 tons vacuum salt plant's production. CSJT also did a lot of specific work in cooperation with the construction of gas storage cavern. The first is to speed up the construction of 600,000 tons vacuum salt plant. Under CSJT's meticulous organization and efforts, the plant was formally put into production in June 2004, which increased the capacity of brine treatment, promoted the development of local salt industry enterprise, also provided the guarantee for the construction progress of gas storage cavern. The second is to transform the fresh water supply system, build new water-lifting stations and send condensate water from the vacuum salt plant to the cavern construction site through newly built twenty-kilometer backwater pipeline, meeting the demand of fresh water for construction of gas storage cavern; The third is to provide eight brine producing wells for West-East Gas Pipeline Company, inject once more the fresh brine produced in the process of cavern construction to the underground for re-circulation, to ensure the final output concentration of brine and greatly speed up the progress of cavern construction. The fourth is to begin one million tons vacuum salt project in October 2008, which can further

enhance the handling capacity of brine digestion, not only to provide a solid foundation for speeding up the construction of gas storage cavern, but also to increase the capability of comprehensive utilization and sustainable development of Jintan Salt Basin.

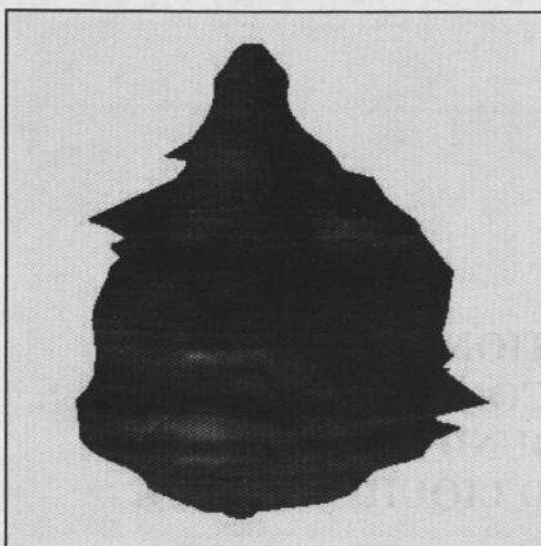
4. SUPPLY NATURAL GAS TO JINTAN CITY

With the underground gas storage cavern project carried out in Jintan, as well as natural gas sales agreement successfully signed by West-East Gas Pipeline Company and Jintan Ganghua Gas Company provided the conditions for Jintan people to economically and safely use the natural gas, indicating that Jintan City has really entered the era of pipeline natural gas. It will effectively push forward the readjustment of industrial structure, improvement of urban quality and the energy-saving and emission reduction work. According to the agreement, West-East Gas Pipeline Company supplies natural gas to Jintan Ganghua Gas Company from 2008 and ultimately the gas supply will reach 30 million cubic meters per year.

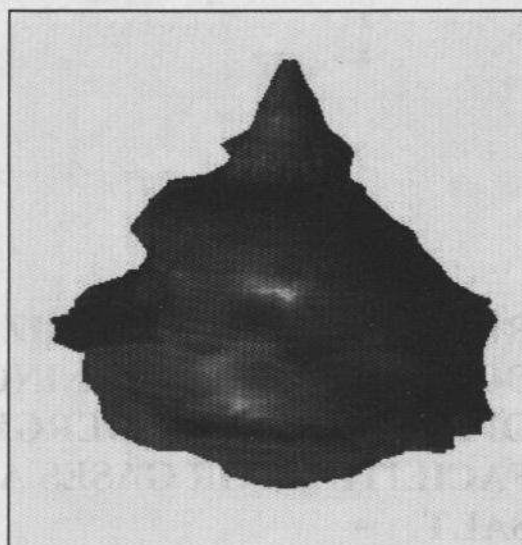
5. COMPREHENSIVE UTILIZATION OF BRINE WELLS

In the production process of 600,000 tons vacuum salt plant, CSJT purchased the power plant that provided high-temperature steam. In order to reduce operation cost of the power plant and improve the overall operating efficiency of the enterprise, CSJT carried out the feasibility study of CAES (compressed air energy storage) power station project. The core of this research project is to use salt cavern to store compressed air. When the power consumption is low, the compressed air will be stored to generate power for peak load use.

In September 2008, West-East Gas Pipeline Company made use of sonar instruments introduced from abroad to measure the salt cavern shape of brine wells Mao15 and Mao16, obtaining the clear cavern image, which offered the support for the feasibility study of the construction of CAES Plant.



M15



M16

6. ACHIEVEMENTS GAINED BY BOTH PARTIES DURING COOPERATION

West-East Gas Pipeline Company acquired the success of the conversion of brine well cavity to gas storage cavern, forming the natural gas storage capacity of 110 million cubic meters, emergency gas supply of 50 million cubic meters, peak regulating gas production of 30 million cubic meters. The first batch of the emergency gas for the safe operation was obtained, providing support for safe operation of the West-East Gas Pipeline.

West-East Gas Pipeline Company made use of the increasing brine sales and treatment capacity of CSJT to gradually speed up the construction progress of underground gas storage cavern. The construction capacity of 1,800 cubic meters per day has been reached presently. With CSJT'S annual production capacity of one million tons vacuum salt project completed and put into production, the construction of gas storage salt cavern will be further accelerated.

Taking the chance of West-East Gas Pipeline Company constructing underground gas storage cavern in Jintan, and making full use of its advantages in geography, resource and other aspects, CSJT gained great achievements through many years of development. Now the company governs four big salt mines, three brine-transporting pipelines with a length of 21.8 kilometers and annual

throughput capacity of 3,500,000 tons salt, a brine refining plant with an annual handling capacity of 600,000 tons, a brine storage tank of 10,000 cubic meters, a special quay with a yearly throughput capacity of 1,350,000 million tons brine, a special quay with a yearly throughput capacity of 2,000,000 tons vacuum salt, a single set of salt and sulphate combined plant with an annual capacity of 600,000 tons which was the world's largest, and a power plant. Now the accessory project of Jintan gas storage cavern, namely the vacuum salt plant with annual output of one million is in construction. CSJT plans to reach an annual output of 2,000,000 tons of refined salt, 1 million tons of liquid salt and to achieve annual sales income of 20 million Yuan, forming a complete salt chemical products series and diversified product types, and becoming the big salt storehouse in East of China and Chinese new salt city.