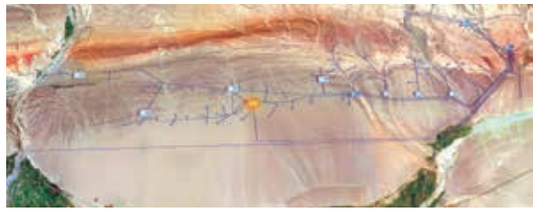
Integration of Ground and Underground Engineering

Selecting a most favorable place for the gas processing plant

The amount of earthwork was reduced and the engineering was more convenient with less costs. The gathering and transportation pipeline is in a fishbone shape to minimize the mileage, shorten the construction period, and cut down overall investment.



Introducing 3D modeling design and modular construction in ground works

3D modeling was introduced in designing the whole plant and the piping system, greatly improving the design schedule and quality. Factory prefabrication of process piping, pipe fittings and other facilities was adopted during the construction of the plant.

Improving energy efficiency

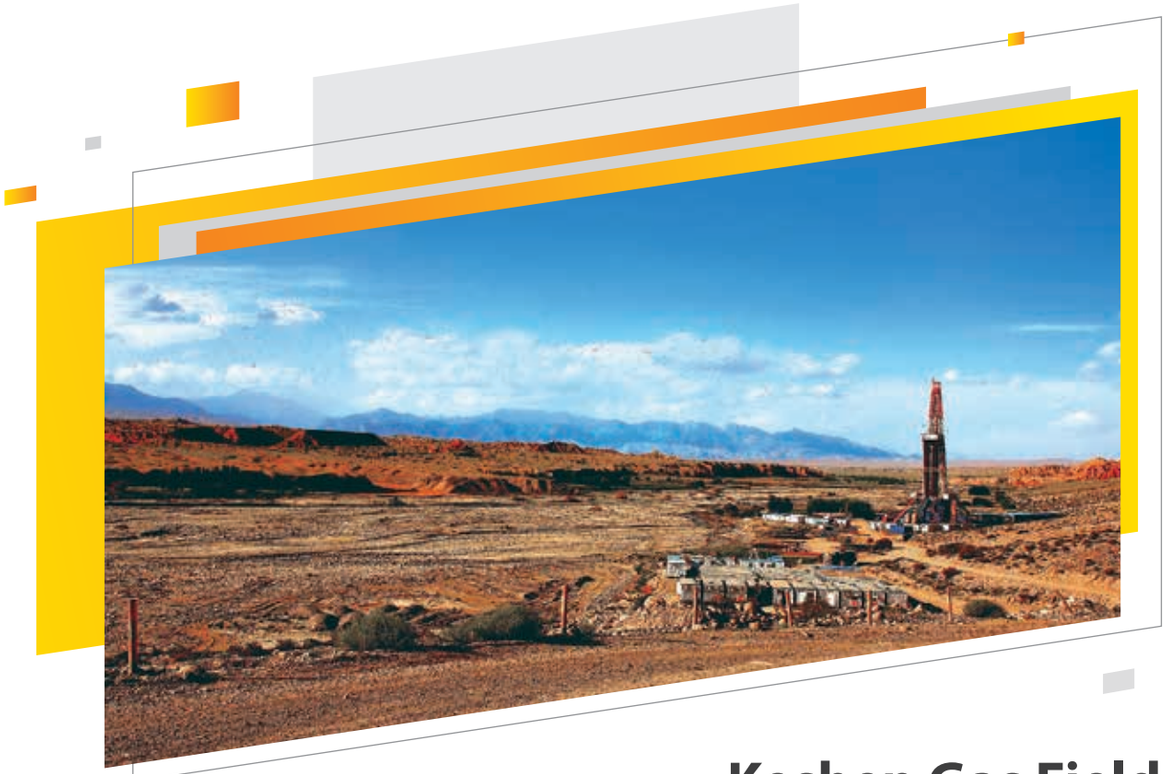
Sophisticated high-pressure throttling refrigeration technology is used in Keshen natural gas processing plant. Compared to traditional technology, it can cut energy consumption by 45%. Simulation software is used to analyze the thermal exchange network and optimize the heat utilization system, in order to minimize energy consumption of heating medium furnace. The gas processing plant consumes only 70% of the energy that other similar-sized plants do.

Project Summary

Development of Keshen gas field began in 2009, and the preliminary development program was worked out in July 2013. In July 2015, the field went on stream as scheduled. Currently, a total of 68 gas producers are capable of delivering 6 billion cubic meters per year. By the end of 2017, Keshen had cumulatively produced more than 20 billion cubic meters of natural gas, serving as a stable supply source of the West-East Gas Pipelines.

The success of Keshen project provides an excellent example for the efficient development of similar gas fields, and it is of great significance to clean energy development and China's improved energy mix.

CNPC



Keshen Gas Field

Energize · Harmonize · Realize

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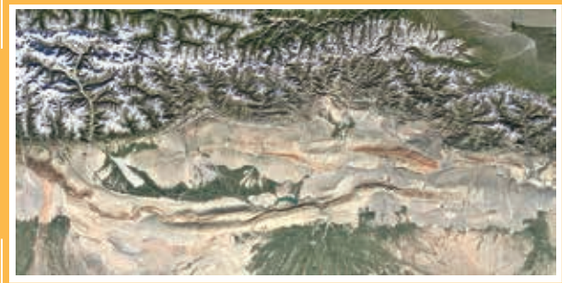
China National Petroleum Corporation

Keshen gas field is located in the mountainous Kelasu structural belt of the Tarim basin in China's Xinjiang Uygur Autonomous Region. Development of the gas field is highly challenging due to its ultra-deep, fractured tight sandstone reservoirs with extremely high pressure. Adopting an integrated exploration and development mode, CNPC built an annual capacity of 5bcm at Keshen gas field within seven years, and achieved excellent HSE performance with "zero pollution and zero injuries".



Geographic and Geological Characteristics

The surface of Keshen gas field is dominated by mountains and ravines without vegetation. The maximum relative relief can be 500m, and the maximum dip angle of outcrops is over 80 degrees. The imbricated gas reservoirs, with a burial depth of 5,000-8,000m, are covered by massive salt layers with a maximum thickness of 4,000m. And the overlying of the salt layers is an overthrust nappe, making the main structural part severely superposed.

Gas Reservoir Features

- Burial depth: 6,500-8,000m
- Temperature: 120-193°C
- Thickness: 300-650m
- Pressure: 116-128MPa
- Structure dip: 30-50°
- Porosity: 1.5-7.0%
- Permeability < 0.1mD

Challenges in Gas Field Development

1. Difficulties in seismic data acquisition, processing and interpretation caused by complex surface and severely superposed underground structure;
2. Difficulties in drilling due to the existence of gravel layers and severely crept salt-gypsum formations;
3. Difficulties in reservoir stimulation due to large burial depth and tight sandstone;
4. High risks in downhole well testing due to high formation temperature and pressure;
5. Difficulties in environmental protection due to the fragile ecological system of the mountainous area.

With the joint efforts of our partners in the project, Schlumberger, Halliburton and Weatherford, we developed integrated solutions and innovative technologies to tackle the difficulties, and achieved the efficient development of the gas field. A total of 383bcm of gas in place were proven, the drilling period was reduced from 522 days to 290 days, single well productivity increased by more than 50%, and the success rate of downhole well testing reached 100%.

Innovative Technologies Applied

1. Seismic data acquisition and processing technology for complex subsalt structure in Kuqa piedmont
2. Technologies for complex subsalt structure modeling and well-pattern optimization
3. Technology for fast and safe drilling of ultra-deep complex wells
4. Technology for fracture network stimulation of fractured massive tight sandstone reservoirs
5. Downhole temperature and pressure data recording approach for ultra-deep, ultra-high pressure and high temperature wells