



# Gas-lift Recovery Technology

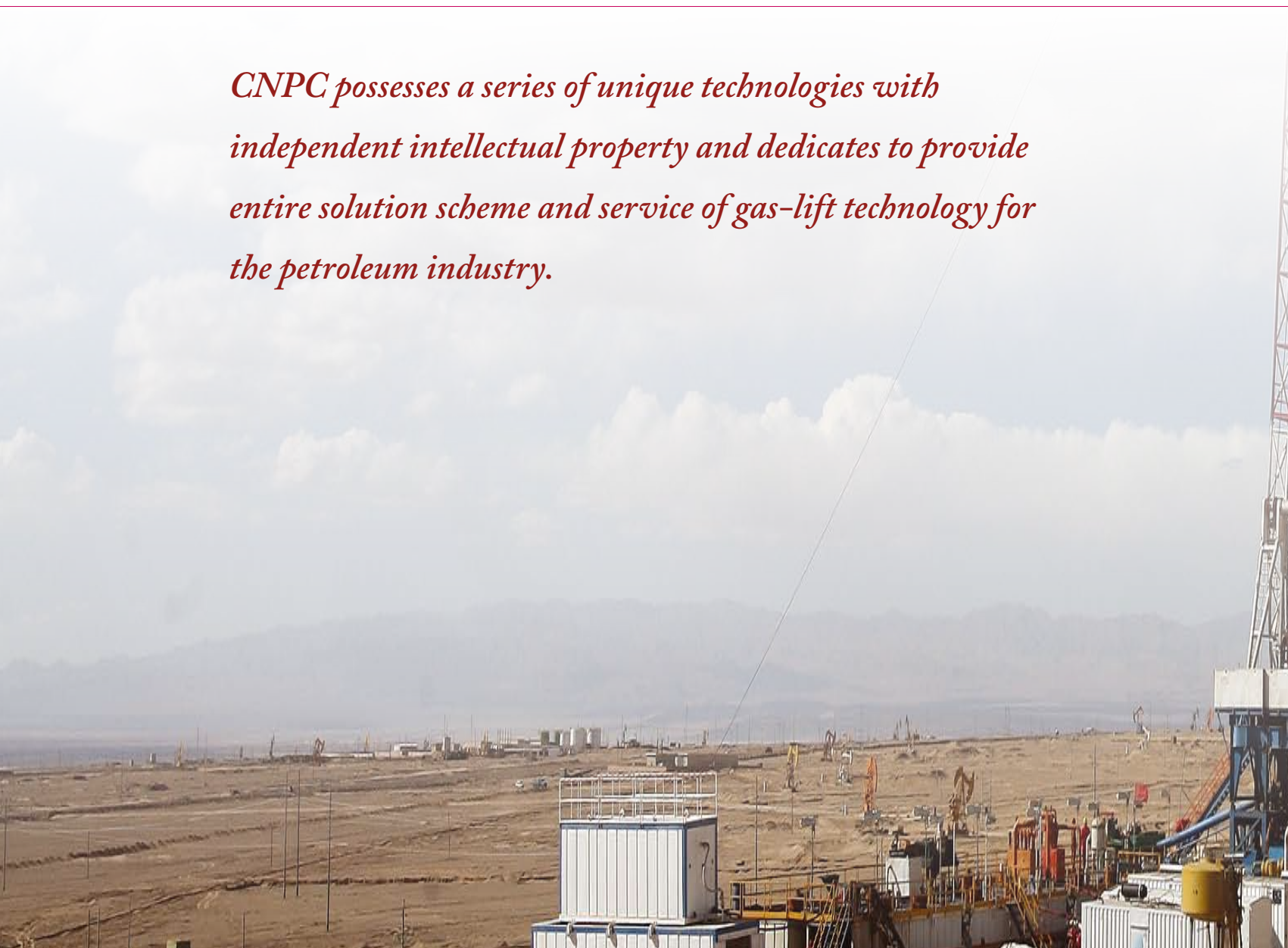
Science & Technology Management Department

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CHINA NATIONAL PETROLEUM CORPORATION

*CNPC possesses a series of unique technologies with independent intellectual property and dedicates to provide entire solution scheme and service of gas-lift technology for the petroleum industry.*





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China National Petroleum Corporation (CNPC) is a state-authorized investment agency and a state holding company. As an integrated oil company of cross-regions, cross-industries and cross-countries, it adopts modern enterprise system to realize the integration of upstream and downstream operations, internal and external trade and production and marketing. CNPC has 17 upstream companies, 33 downstream companies and 36 large-scale marketing companies. It is China's largest producer and supplier of oil and gas, and also of refined oil products and petrochemicals. In 2010 CNPC produced 105 million tons of crude oil and 72.5 billion cubic meters of natural gas, while crude processing volume reached 135 million tons. The total revenue of RMB1, 720 billion with a profit of RMB172.7 billion had been achieved the same year. Its profit is among the highest of the domestic enterprises in China.

CNPC was ranked 10rd in Fortune Global 500 in 2010 and 5th among global top 50 oil companies.

CNPC strictly follows by the combined strategies of increasing resource capacity, expanding market shares and consolidating the international role, and persists in regarding technical innovation as a key framework to advance technological progress. To develop its core businesses, focuses will be placed on the solutions of key bottleneck technologies and key proprietary technologies. Thanks to continuously improving of the technical innovation system, optimizing the configuration of technological resources and strengthening the construction of strong talent teams, CNPC's technological creativity has been considerably upgraded. Consequently, a large number of technologies have been developed independently, with its own intellectual property.

The Gas Lift Technology (GLR) is one of the representatives for major innovations.



# 1

## INTRODUCTION



CNPC is an institute which can provide the entire solutions for Gas-lift Technology. It possesses a lot of excellent professional talents, combined with matured gas-lift tools and equipments to provide a complete set of high-quality gas-lift production services.

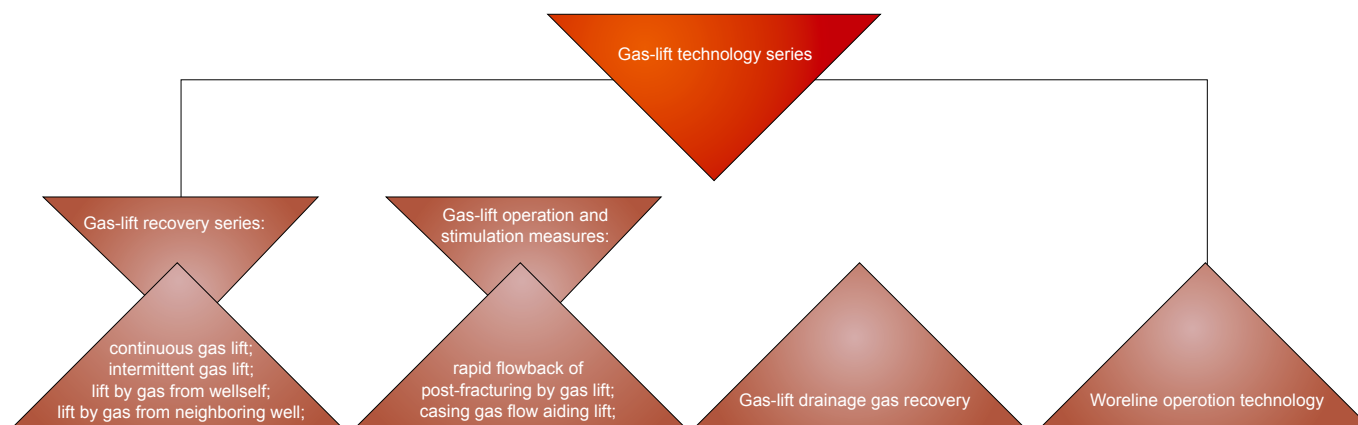
CNPC accumulates rich experiences in Gas-lift Technology, provides a complete set of services, including gas-lift scheme compilation, gas-lift optimization design, tools manufacturing, testing, gas-lift fault diagnosis and gas-lift production management and well completion, etc.

Since 1991, CNPC has built and perfected its quality and standard system, formed 8 mature gas-lift technology series and 29 unique technologies, and developed the gas-lift tools of 5 categories, 48 kinds and 97 specifications that matching the production

strings of three specifications. The performance indices of all kinds of technologies reach the advanced international level in the same type.

These technologies have been widely applied to ten oilfields in China and the overseas service markets in Kazakhstan and Sudan. In Kazakhstan, gas lifting is currently applied to more than 250 oil wells in Zhanazhol Oilfield and the annual production reaches to 2.2 million tons, which becomes the largest gas-lift unitization oilfield by the scale of single onshore reservoir world wide, Since 2001, the accumulative oil increase has reached 2.81 million tons.

### 8 technology series of gas lift:



# 2

## UNIQUE TECHNOLOGIES

### 2.1 Gas-lift Recovery Technology series

#### 2.1.1 Continuous Gas-lift Recovery Technology

Continuous Gas-lift Recovery Technology is to continuously inject a certain amount of high pressure natural gas into the tube through the gas lift valve in casing annular, and fully mixes with the borehole fluids to form mixed fluid so as to reduce the borehole fluid density. Under the relatively low bottomhole flowing pressure, the mixed fluid will be lifted to realize the gas-lift recovery.

Continuous gas-lift recovery of CNPC has been formed:

- Gas-lift recovery program compilation technology;
- Gas-lift well optimization design;
- Gas-lift fault diagnosis;
- Production management technology;
- Auxiliary downhole tools;
- Gas-lift well system optimization.

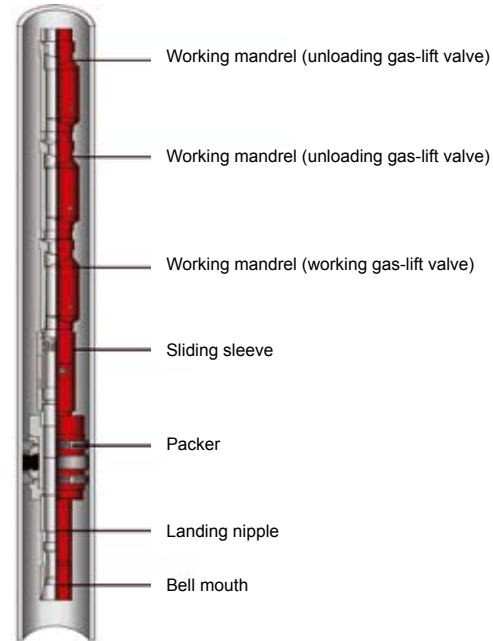
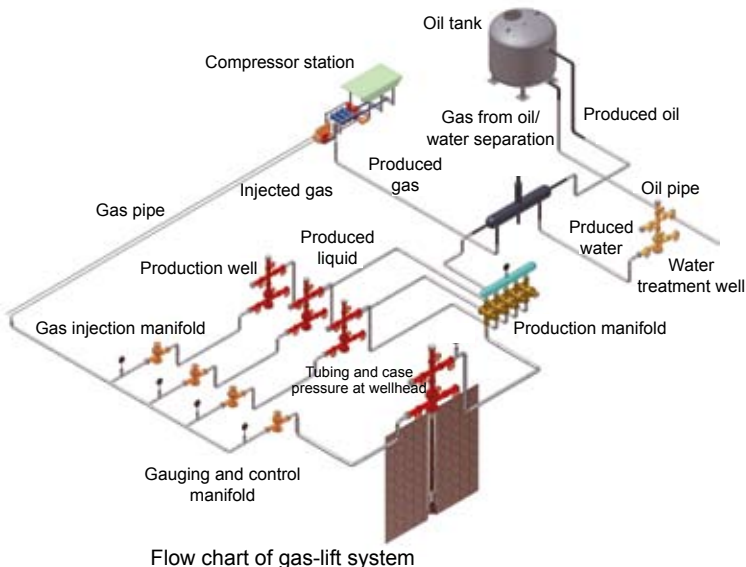


Diagram of continuous gas-lift recovery and completion string

The features of continuous gas lift include:

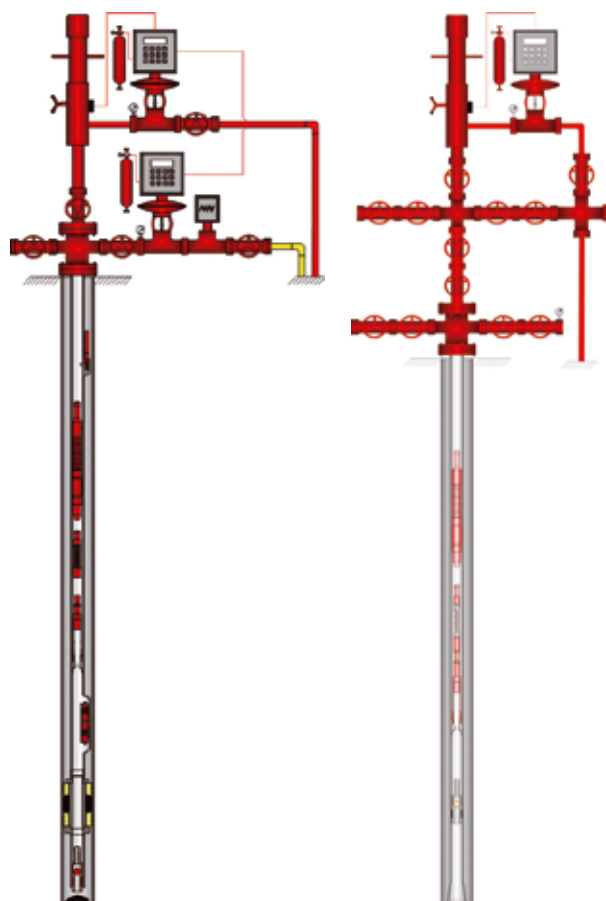
- (1) A wide range of applicable production (142.9-22714.3bpd), production can be adjusted on the ground;
- (2) It is quick to fit in with the surroundings and is not affected by sands, gas, well deviation and severe surface environments, etc;
- (3) Easy operation, easy realization of centralization and automatic management, low operation cost.



### 2.1.2 Plunger Gas-lift Recovery Technology

Plunger Gas-lift Recovery Technology is a kind of intermittent gas-lift recovery technologies. BY using the downhole plunger as gas-liquid interface, high pressure gas is intermittently injected to push both of the plunger in the casing and the fluid above the plunger to reach the ground, as a way of mechanical recovery for oil and gas well production. The plunger is used to separate the lifted fluid and high pressure gas to reduce the slippage loss between the gas phase and liquid phase, so as to increase the lifting efficiency of the gas lift. This technology is mainly used in the low production and low pressure wells and can be divided into external gas source plunger lift and plunger gas lift by crude gas according to the different gas sources.

There are many advantages of the Plunger Gas-lift Technology (1) Downhole tools carry out with wireline, which is easy and feasible; (2) The plunger can be



External gas source plunger lift

well-Self gas source plunger lift

maintained and repaired without tripping out the casing, the maintenance and repair cost is low, and the operation cost is far less than other artificial lifting ways; (3) The mechanical friction of the plunger hinders the wax deposition, the effect of wax prevention is obvious; (4) The land occupation is less without pollution, which is suitable to the oilfield production in the residential and offshore place.

### 2.1.3 Gas-lift Recovery by Crude Gas Technology

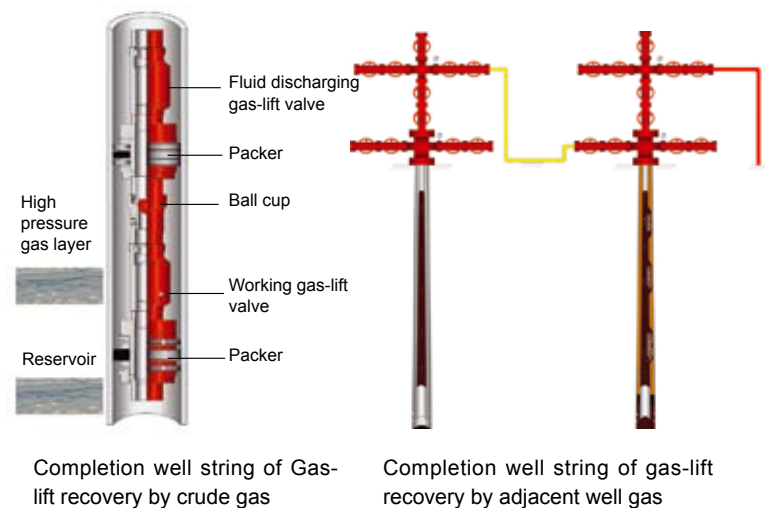
Gas-lift recovery by crude gas is a kind of gas-lift developing way in view of the special oil well with independent layers for oil and gas. This technology does not need the external high pressure gas source and only by using the HP gaslayer itself to neconery. The gas from the oil well has been reasonable match injected into the casing through the gas valve, the gas mixes with the well fluid fully to form mixed fluid inside the casing so as to reduce the well fluid density and realize the oil lifting.

The technology not only can control the gas production of the high pressure gas layer reasonably but also realize the purpose of oil lifting.

The features of the gas-lift recovery by cnude gas are: (1) low oil production cost; (2) use the gas-lift valve to control the injecting volume from the gas layer output, prevent the interlayer interference caused by the oil-gas producing to realize the multi-layer oil and gas commingled production; (3) an entire system of a single well, meet the demand of isolated oil production; (4) completion string can realize testing, well killing and non-killing well operations.

### 2.1.4 Gas-lift Recovery by Adjacent well Gas Technology

The gas-lift recovery by the adjacent well gas is built on the same Principle with that of the gas-lift recovery by crude gas. The different is that in terms of the block with the conditions of high pressure gas well the high pressure gas well can replace the high pressure compressor to act as gas source for gas-lift production, and greatly reduce the a lump sum investments of gas-lift recovery.



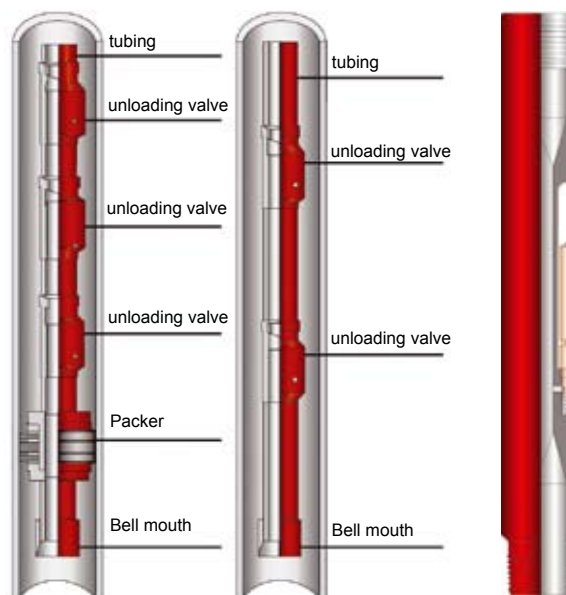


## 2.2 The extended application of the Gas-lift Technology

### 2.2.1 Rapid flowback of gas-lift after fracturing operation

“Fracturing gas lift rapid flowback technology” refers to a directly gas lift way which equip the high pressure gas lift tool on the fracturing string to realize the rapid flowback of fracturing fluid without tripping out the fracturing string after the fracturing treatment. This technology as a combination of fracturing technique and gas lift technology is mainly used in the fracturing fluid flowback in the low permeability reservoir with low formation pressure. And it can obviously improve the flowback efficiency of the fracturing fluid, shorten the flowing time and is of an essential to intensify the fracturing results and improve oil well effective utilization. Three patents have been developed in the case of the technology: “double eccentric and fixed downhole controlling tool used in oilfield”, “integrate gas-lift valve eccentric fix tube used in oilfield” and “gas-lift string of fracturing discharging operation”.

The features of this technique include: (1) pressure bearing capacity of the string up to 14,500psi; (2) rapid flowback after the fracturing without tripping out the string, simplify the operation sequence, shorten the retention time of the fracturing fluid in the formation and reduce the formation damage; (3) rapid flowback velocity of the fracturing fluid, whole well flowback time is about 7 hours with 5' casing in 3,000m deep well; (4) large flowback volume, flowback to the well bottom once only; (5) less matching equipments, simple and reliable techniques.



Separate layer  
fracturing flowback  
technology

Multi-layer fracturing  
flowback technology

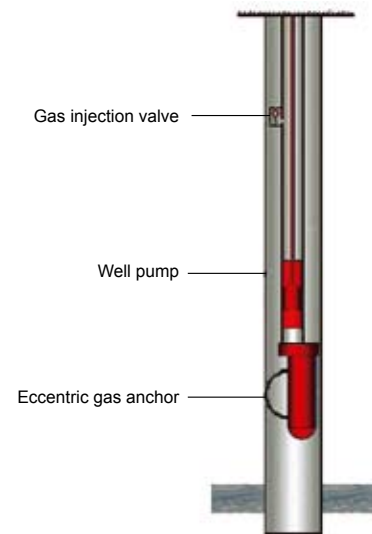
Double eccentric working  
unit under high pressure



### 2.2.2 Casing Gas Assisted Lifting Technology

This technology mainly aims at the rod pump lift well with high gas/oil ratio, installs gas injection valve for pipeline in place to use as the gas preventing tools. Before the fluid enters the pump, most gas is separated and enters the annular space through the gas preventing tools, such as gas anchor, etc., then the gas accumulating in the annulus enters the tube through the gas injection valve, the liquid cylinder gradient above the injection point decreases so that excreta pressure of the pump and the pump and rod load can be reduced to improve the pump efficiency. In addition, in view of the pumping wells with blowout phenomenon in the casing, the injection point is installed under the wax point, which can prevent casing wax, effectively postpone the hot washing period of the oil wells, improve the production aging and reach the purpose of production growth.

The technology can: (1) reduce the excreta pressure of the pump, discharge the gas in the pump in time, and increase the volumetric efficiency of the pump by 10%; (2) decrease the liquid cylinder load and stroke loss by 1/3 to 2/3; (3) prevent blowout in the casing and casing wax during the oil well production; postpone the rod and pump life and reduce the pump leak; (4) under a certain circumstance, further deepen setting the depth of pump, reduce the bottom flow pressure to increase the production by 20%-30%; (5) even if gas injection fails or the gas injection valve is blocked, the oil wells can produce normally.



Work principle of casing gas assisted lifting





### 2.3 Gas-lift application of dewatering gas production in gas well

The Dewatering Gas Production by Gas-lift Technology is to discharge the accumulated water in the gas well bottom according to the gas-lift recovery download principle to reduce the flow pressure in the gas well bottom and resume the normal gas well production and increase the gas well production.

The main features of this technology are: (1) fully use the formation energy, resume the flowing production after drainage, save the development cost, resume drainage for many times, easily measure and acquire the liquid level and pressure data; (2) half-closed gas lift strings can avoid the back pressure to the well bottom caused by the gas injecting pressure; (3) easy design and installation of the equipments, easy management and low economic input.

### 2.4 Wireline Operation Technology

The Wireline Operation Technology is a construction way of downhole operation and the wireline winch is used to run the wireline tools in the tube. This technology can be used in the downhole test, running and pulling of gas-lift valve, gas injection valve and water distributor, running and pulling of plunger gas-lift tool and downhole nozzle, running and pulling of switch controlling the downhole sliding sleeve and drops, downhole accident treatment and prevention, and other special operations.

Wireline operation is the assistant technology of gas-lift technology, the above gas-lift production implementation needs the wireline operation. Because the downhole tool path of the gas-lift string is consistent with the tube, so the production allocation, fault removal and production data testing, etc. can be realized by the wireline operation. And the technology has many advantages, such as easy operation, short operation time and no damage to the reservoirs, etc. At present, Tuha has developed 29 kinds of tools that meet the wireline operation of 60.3mm" and 73mm" tube. For satisfying the customer requirements, tools can be customised in Special size as well.



Wire cutter

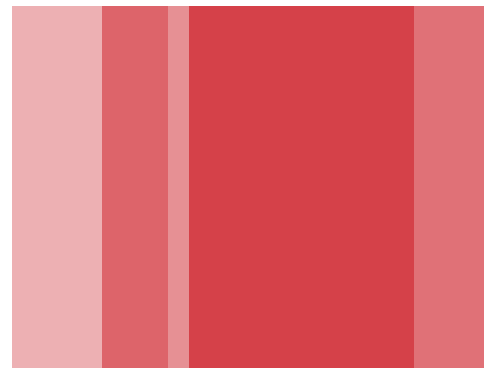


Chain jar knocker



Movable joint







## 2.5 Typical patents introduction

### Mechanical blocking and unblocking packer (ZL992 07783.4)

In order that the pressure bearing capacity is not forced by the unblocking, CNPC specially designs this mechanical blocking and unblocking packer of bidirectional slips.

### Double eccentric fixed downhole controlling tool used in oilfield (ZL20032 0100404.5)

This is a double eccentric fixed downhole controlling tool. "Double eccentric" refers to eccentric liquid passing pore and eccentric gas passing pore. The main feature is that the double eccentric structure saves the transverse space, improve the tool intensity, which can meet the oil well operation of the casing inner diameter of less than 121mm.

### Screw joint running and pulling eccentric downhole control tool used in oilfield (ZL20032 0127762.5)

This tool is to provide working material for the controlling tools of gas-lift valve which can be placed in the tool or pushed out on the ground or in the well bottom; this tool has no welding seam with good anti-corrosion performance.

### Integrate gas-lift valve eccentric installing barrel used in oilfield (ZL200620001497.X)

To meet the gas-lift drainage requirement after the acidizing and fracturing and gas-lift valve eccentric installing barrel of the H<sub>2</sub>S oil well, Tuha Gas-lift Technology Center specially designs this integrate gas-lift valve eccentric installing barrel to improve the bearing capacity of the tool and the anti-corrosion of H<sub>2</sub>S and reduce the production probability of hydrogen embrittlement.

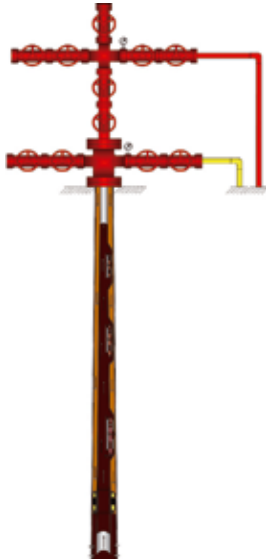


**Circular sliding sleeve used in oil and gas field  
(ZL200620158759.3)**

This is a core matching tool of gas-lift completion string in oil and gas well, repeated switch can be realized by running in the special displacement tool with wireline winch to communicate the casing annulus and provide the circular channel for production string, which can be used for well killing or washing; in view of separate layer production string, matching packer can be used for separate layer production.

**Gas-lift string of fracturing drainage operation  
(ZL200620158616.2)**

To realize the gas-lift drainage after fracturing and continuous gas-lift recovery, Tuha Gas-lift Technology Center specially designs this string which is characterized by high bearing capacity, rapid drainage and continuous gas-lift production without tripping out the string.



Gas-lift string of fracturing  
drainage operation



# 3

## TYPICAL CASES



### 3.1 Continuous Gas-lift Recovery in Tuha Oilfield

In June 1993 and June 1996, two compressor stations were built in Shanshan Oilfield and Qiuling Oilfield respectively, 9 compressor groups and 13 gas distribution stations were installed, and 326 well times were completed with gas-lift completion accumulatively. The average oil production growth in Shanshan is 153.6bpd, and the accumulated oil production growth in the oilfield is 57Mbbl. The average oil production growth in Qiuling is 82.9bpd, the recovery rate in gas-lift area is 4%. Therefore high efficient development of low permeability oilfield is realized.

### 3.2 Continuous Gas-lift Recovery in Zhanazhol Oilfield

Since October 2001, Zhanazhol Oilfield has built 3 compressor stations and installed 8 compressor groups. There are 245 wells with gas lift in the oilfield which becomes the largest gas-lift oilfield of a single reservoir worldwide, with the annual oil production of 15.71Mbbl. The average production growth of a single well is 150.0bpd, while the accumulative production growth at present is 20.07Mbbl. This technology has become a major production growing measure to ensure the oilfield rapid development with high efficiency.

### 3.3 Fault diagnose and technology consultation

In September 2005, CNPC provided production Well A10 in Pinghu Oilfield of CNOOC Donghai Company with fault diagnose and optimization. Through the analysis, combined with the actual production conditions of the platform, our experts proposed technical parameters optimization and amending measures. After the implementation, the production of well A10 increases from 1,260bpd to 3,780bpd. In July 2007, CNPC provided gas-lift technology consultation for Jidong Oilfield and got well effect in the pilot test.







### 3.4 Gas-lift Recovery by the Gas from Adjacent Well

Considering the quick expansion of gas-lift scale in Zhanazhol Oilfield and the lagging ground engineering construction, Tuha Gas-lift Technology Center developed gas-lift recovery by the gas from adjacent well which fully uses the high pressure gas source from adjacent well and reduces the ground equipment investment. Since 2002 there are totally 42 times were put into operation, the commissioning successful rate is 100% with the average single well production growth of 151.8bpd, which is equivalent to saving the ground investment of RMB17 million. To fully employ the gas reservoir energy, the center compiled a construction scheme of gas lift recover by the gas from adjacent well for Sudan Block 6, two wells was completed in 2007, with the average single well production growth of  $243.3\text{m}^3/\text{d}$  per day.

### 3.5 Rapid Flowback Of Gas-lift Technology

In May 2003, the Rapid Gas-lift Flowback Technology was successfully applied in Tahe Oilfield. is used for Oilfield and it is used for induced flow after acidification in well TK715, with in Well TK715, with the highest construction pressure of 94MPa, the oil pressure of the well after induced flow 12MPa, the casing pressure 2900psi, and the daily oil production of 170t under the



4mm choke control. since then, this technology has been used as the only flowback method for oil well after acidification and popularized in full scale, after the flowback rate reaching 85%,the natural flow was resumed to realize the high efficient rapid flowback with.

In June 2007, the Rapid Drainage of Gas-lift Technology provided by Tuha gas-lift center was successfully applied in Well Qing2-44 of Qingxi Oilfield, Yumen, the well was not able to flow after induced flow. After 13 hours' gas-lift drainage, the back flowing volume was  $115\text{m}^3$ , a stable production of  $140\text{m}^3/\text{d}$ .

### 3.6 Wireline Operation Technology

From 1993 to December 2006, the Wireline Operation Technology was applied to throwing in and pulling out 400 well times and 1300 valves were replaced in gas-lift wells and water injection wells, with the successful rate of 97.5%.Throwing in and pulling out 10 valve times with a success rate of 100% was realized by using the distributing valve on the 35MPa high-pressure separate layer gas injection wells, while the same success rate was performed in installing 11 well times downhole chokes. Moreover, CNPC removed the troubles of 55 well times with 95% throwing in and pulling out success rate. This technology has widely applied in Tuha Oilfield and Zhanazhol Oilfield in Kazakhstan, etc.



# 4

SCIENTIFIC  
RESEARCH  
EQUIPMENT

## Gas-lift simulation test system

Gas-lift simulation test system can simulate all the processes of the gas-lift recovery with the testing well and multi-types of equipments. It can be used to test the performance and material of the gas-lift matching tools, and provides the conditions for the research and test of gas-lift technology.



Commissioning table of gas-lift valve



Gas-lift valve performance tester

## Commissioning table of gas-lift valve

Commissioning table of gas-lift valve is a major equipment of gas-lift engineering which is mainly used in check and test of gas-lift valve and pressure adjustment, etc.

## Gas-lift valve performance tester

Through testing the system equipments, evaluate the gas-lift valve performance and predict the downhole working conditions to ensure and improve the manufacturing quality of the gas-lift valve. Apply the testing data to the field production, for effectively guiding the production and improve the technical level of gas lift, and the production efficiency of gas-lift system.



# 5 QUALIFICATIONS AND STANDARDS



## Enterprise qualification

CNPC has continuously obtained the ISO9001 Quality System Certification since the first pass in 2000, which gets the requisite qualifications for doing the research on new techniques of oil recovery and providing to related products.

In 2006, Tuha gas-lift center was listed in the technology research center sequence of CNPC, took charge of gas-lift oil recovery research, new technology development and application, and set up a leading role in China gas-lift domain.

## Technology standard

During the gas-lift technology research, more than 60 items of relative gas-lift standards published both at home and abroad are quoted, in which there are 7 items of API gas-lift standards, the manufactured gas-lift valve meets the standard of API Spec 11V1, quoted from Gas-lift valve, orifice plate, backflow valve and balance valve, the established quality management system accords with the API Spec Q1-2003, quoted from Oil, petrochemical and natural gas industry quality specification, resulting in the gas-lift products manufactured by the center go to the international market.

The matching gas-lift technical design, fault diagnose, construction operation, drainage and gas production, gas-lift downhole tool repair, check and test and performance testing have been nesearched in accord with the relative standards of Chinese oil and gas industry. The developed anti-H<sub>2</sub>S gas-lift product meets NACE MR0175 standard, which adapts the corrosion medium environment of H<sub>2</sub>S and CO<sub>2</sub>.

# 6

SPECIALISTS



Lei Yu, Senior engineer, President of Tuha Petroleum Engineering Technology Research Institute. He was engaged in the gas-lift recovery technology research in 1991, and has been trained for gas-lift recovery technology in American Tulsa University, and made remarkable contributions to the gas-lift recovery in Shanshan and Qiuling of Tuha Oilfield. He organizes the research of two state projects and two CNPC projects, obtained 5 item results at provincial level and published many papers.



Wang Qiang, Senior engineer, Chief Engineer of Tuha Petroleum Engineering Technology Research Institute. In 1996 he was engaged in the mechanical oil production and oversea market development, took charge of the gas-lift recovery scheme compilation and well completion research, etc. He has been awarded 4 research results at provincial level, 3 national patents. And several papers have been published. In 2001 he went to Zhanazhol Oilfield Kazakhstan of and was in charge of the technical service of gas-lift recovery, he makes remarkable contributions to opening the external market.



Li Yong, Senior engineer, Director of Oil Recovery Mechanical Department of Tuha Petroleum Engineering Technology Research Institute. In 1988 he was engaged in the downhole tools research and organized the scientific project research, took charge of over 40 kinds of downhole tools development, in which 8 items of tools got national patent, such as hydraulic switch sliding sleeve and retrievable packer, etc. he was evaluated as technical expert of Tuha Petroleum Exploration and Development Headquarter for many years.



Wang Zhensong, Senior engineer, Chief Engineer of Central Asia Project Department of Tuha Petroleum Engineering Technology Research Institute. In 1996 he was engaged in the mechanical oil production of Kazakhstan research and technology application, and has worked in Zhanazhol Oilfield. He is in charge of the market development in Sudan and plays an important role in the gas-lift technology application. He gets 10 more items of scientific achievements and 4 items with national patent. And he is evaluated as scientific model of the engineering technical institute.





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