



Coiled Tubing Technology & Unit



Science & Technology Management Department, CNPC



Coiled Tubing Unit, A Universal
Machine in Oilfield Development!



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China National Petroleum Corporation (hereinafter referred to as CNPC) is an oversized petroleum and petrochemical conglomerate established in July 1998 on the basis of the original CNPC, and its system was well reformed in December 2017.

CNPC is a wholly state-owned company and a comprehensive international energy company integrating production, refining, transportation, sales, storage and trade. The main business of CNPC covers domestic and foreign oil and gas exploration and development, refining and chemical engineering, oil and gas sales, pipeline transportation, international trade, engineering technology services, engineering construction, equipment manufacturing, financial services, new energy development, etc. CNPC ranked third among the 50 large petroleum companies worldwide and fourth among the 500 large companies globally according to Fortune in 2017.

CNPC carries out the resource, market, internationalization and innovation strategy, sticks to the science and technology development idea "main business strategy drive, development objective orientation and top layer design" and the guideline "self-innovation, key crossing, support to development and guide to future", and continuously promotes science and technology advance, increases science and technology innovation capacity. CNPC has obtained a large number of advanced practical technologies with independent intellectual property rights taking national key special science and technology projects as the head, the Company's key special science and technology projects as the core, key field tests as the grasp and key equipment, software, products and standards as carriers.

Coiled tubing unit and technology are one of representative significant innovations.

OFFERING ENERGY SOURCES, CREATING HARMONY



1 Introduction

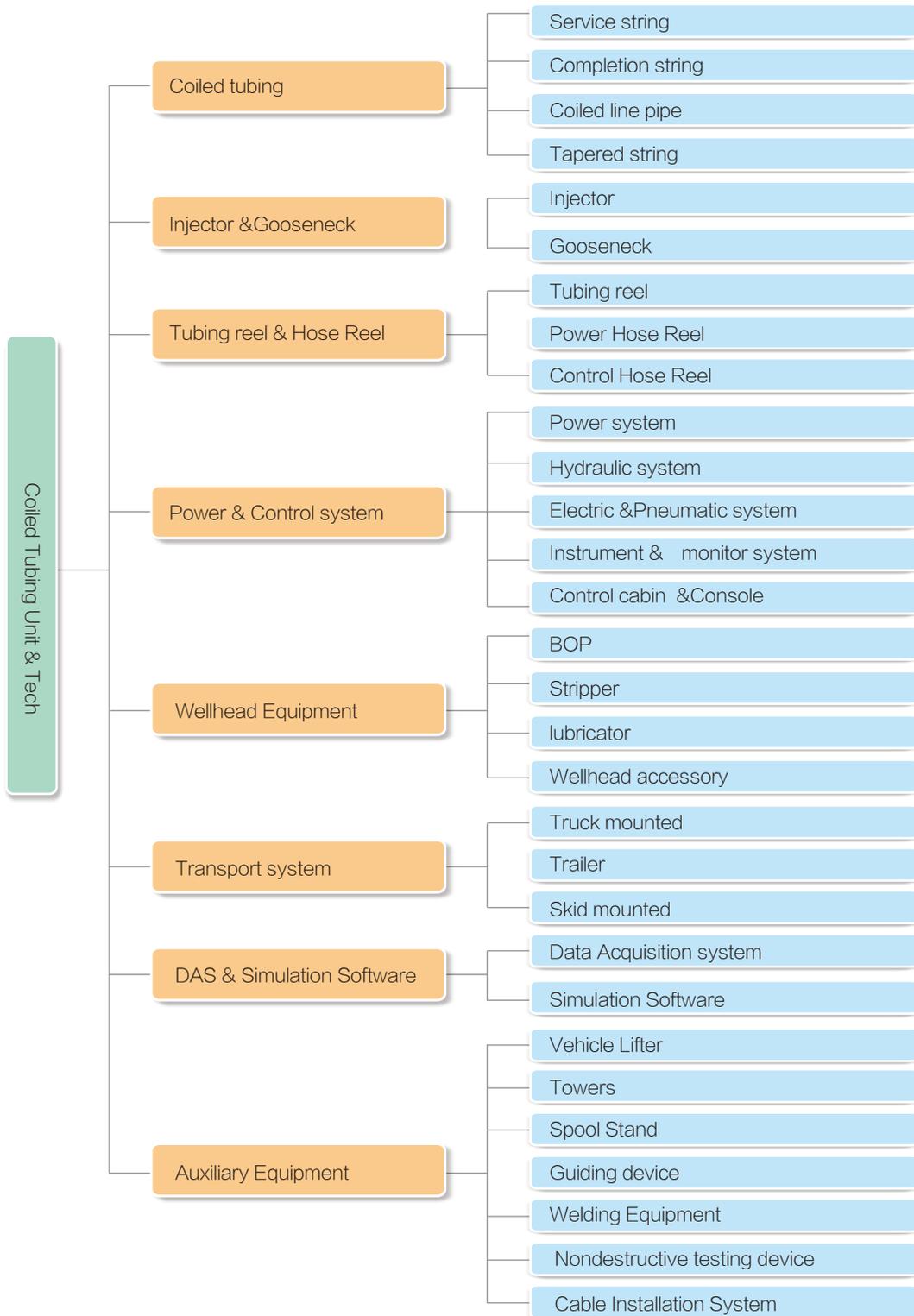
Coiled tubing is also called flexible tubing, which was originated from submarine pipeline engineering during the Second World War. Since the early 1960s, the coiled tubing operation technology has been applied in the oil industry. The development of the modern science and technology has given a vigorous boost to the development of and advance in the coiled tubing operation technology. In the 1990s, the coiled tubing unit was famed as “universal operation equipment” and widely applied in fields including drilling, completion, oil production, workover, gathering and transportation, etc. The number of coiled tubing units in use has reached over 2089 in the world. The coiled tubing unit is playing a more and more important role in exploration and development of oil and gas fields. The application practice of the coiled tubing operation technology in China for over 30 years proves that coiled tubing can be used in multiple operations such as sand washing, well cleanout, acidification, wax removal, cement squeezing, gas lifting, fishing, cement plug drilling, low speed fracturing, pipeline purging, etc. in land and offshore oil and gas wells. Especially with the continuous increase in the number of directional wells and extended reach wells as well as the development of slim hole drilling technologies, the advantages of coiled tubing are more and more remarkable and its applications are more and more extensive.

The coiled tubing unit is applied mainly in sand washing and well cleanout, drilling and milling, gas lifting and induced flowing, fishing, drainage, high freezing point oil plugging removal, wax removal and plugging removal, ice plugging removal, etc. in terms of workover, fixed point fracturing, separate layer fracturing, uniform acid distribution, dragging acidification, etc. in terms of stimulation, and slim hole drilling, underbalanced drilling, old well deepening, sidetracking of horizontal wells, etc. in terms of drilling.

In response to quick commissioning and severe conditions such as high altitude hypoxia in shallow oilfields, an integrated coiled tubing unit has been provided. The coiled tubing unit can use 1.5” coiled tubing to carry out quick drifting and well cleanout and achieve scale application. With the coiled tubing unit, operations of 2~3 wells can be completed per day, and the annual workload is up to 245 wells* times. The coiled tubing unit reaches the international advanced level.

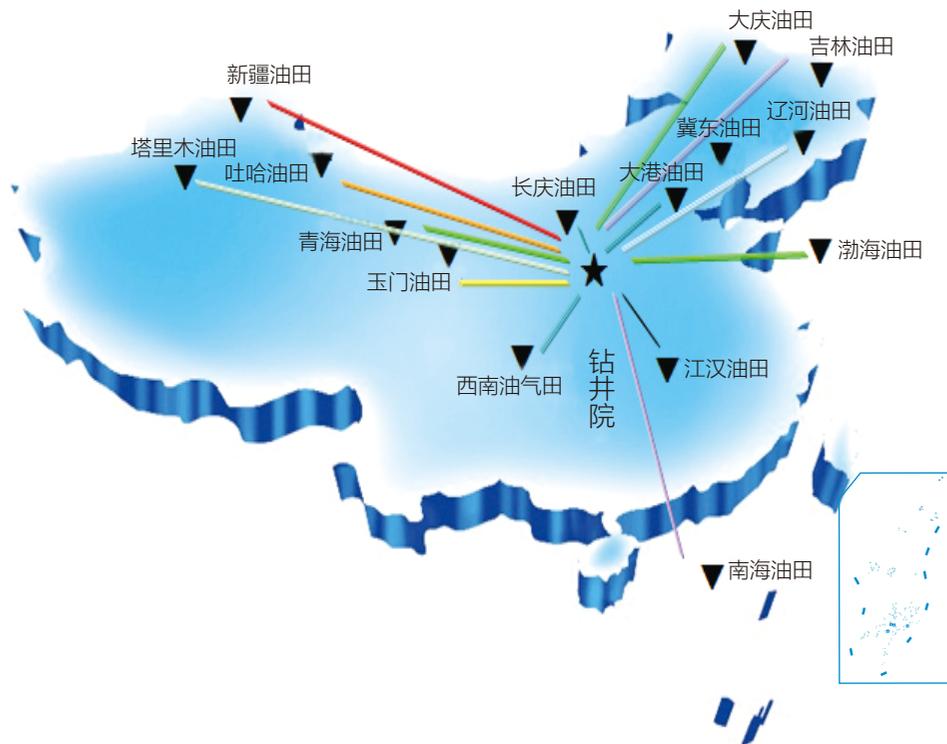
In response to road conditions including mountainous regions, hills, sharp turn, etc., a two-truck mounted large-capacity coiled tubing unit has been provided. The coiled tubing unit uses 2” coiled tubing to carry out conveyed perforation, bridge plug drilling and milling, acidizing and fracturing. After sand packed fracturing of a well with the coiled tubing unit, the production of this well is around 1.3 times that of its adjacent well.

In order to meet the needs of deep well fracturing, a trailer type coiled tubing unit with ultra-large pipe diameter has been provided. The running depth of coiled tubing in well MaHW6014 was up to 5976m; with the coiled tubing unit, drifting, Acoustic amplitude logging, and perforation operations in the 1598m long horizontal section of this well succeeded, thus creating the operation record of coiled tubing running depth and the longest horizontal section in Xinjiang oilfield.



In response to small operation space of offshore platforms, limited crane capacity, explosion proofing and anticorrosion, etc., a dual-purpose land and offshore skid-mounted modular coiled tubing unit has been provided. The coiled tubing unit has been successfully applied in offshore oilfields and has become the main coiled tubing unit of CNOOC for overseas application.

Coiled tubing units in conjunction with the developed tools and technologies have been applied in various operations of thousands of wells including sand washing and well cleanout, nitrogen injection and drainage, well killing, running velocity string, fracturing, downhole tubing cutting, fishing, etc. in China's oilfields such as Liaohe, Jidong, Qinghai, Changqing, Daqing, Dagang, Xinjiang, Sichuan, Jiangnan, CNOOC, etc. and have obtained remarkable effects.



● Market application distribution map

2 Characteristic Technologies

2.1

Basic Types of Coiled Tubing Units

In the 1980s, CNPC began to track, study and develop the coiled tubing unit. At present, CNPC has a large number of excellent scientific research and development talents, professional manufacturers, perfect after-sales service systems and professional service teams. In addition, CNPC has built up China's only coiled tubing equipment laboratory and drilling engineering laboratory and can provide coiled tubing units with reliable quality and stable performance and high quality after-sales services.

CNPC can study and develop series products of multiple models and multiple specifications, including multiple transportation modes such as truck-mounted, skid-mounted, trailer-mounted and mixed ones, etc. The diameter of coiled tubing ranges from 9mm to 73mm, length from 3500m to 9,000m and its max lifting force from 2.5kN to 580kN. More than 40 patent technologies have been formed. CNPC

has obtained the special vehicle manufacturing qualification by China National Development and Reform Commission and formulated the industrial standards such as Coiled Tubing Unit (SYT67612014) and Recommended Practice for Coiled Tubing Operations in Oil and Gas Well Services (SYT6698-2007).

CNPC has developed the coiled tubing technologies involving sand washing and well cleanout, drilling and milling, gas lifting and induced flowing, fishing, drainage, high freezing point oil plugging removal, wax removal and plugging removal, ice plugging removal, etc. in terms of workover, fixed point fracturing, separate layer fracturing, uniform acid distribution, dragging acidification, etc. in terms of reservoir stimulation, and slim hole drilling, underbalanced drilling, old well deepening, sidetracking of horizontal wells, etc. in terms of drilling.

2.1.1 Truck-mounted Coiled Tubing Unit

The truck-mounted coiled tubing unit is widely applied in land operations due to convenient transportation and disassembling. The truck-mounted coiled tubing unit generally includes one-truck mounted type, two-truck mounted type and composite type. The sunken truck-mounted coiled tubing unit has been applied more and more extensively in view of the needs of large-capacity and large pipe diameter coiled tubing operations and poor road transportation conditions in China.



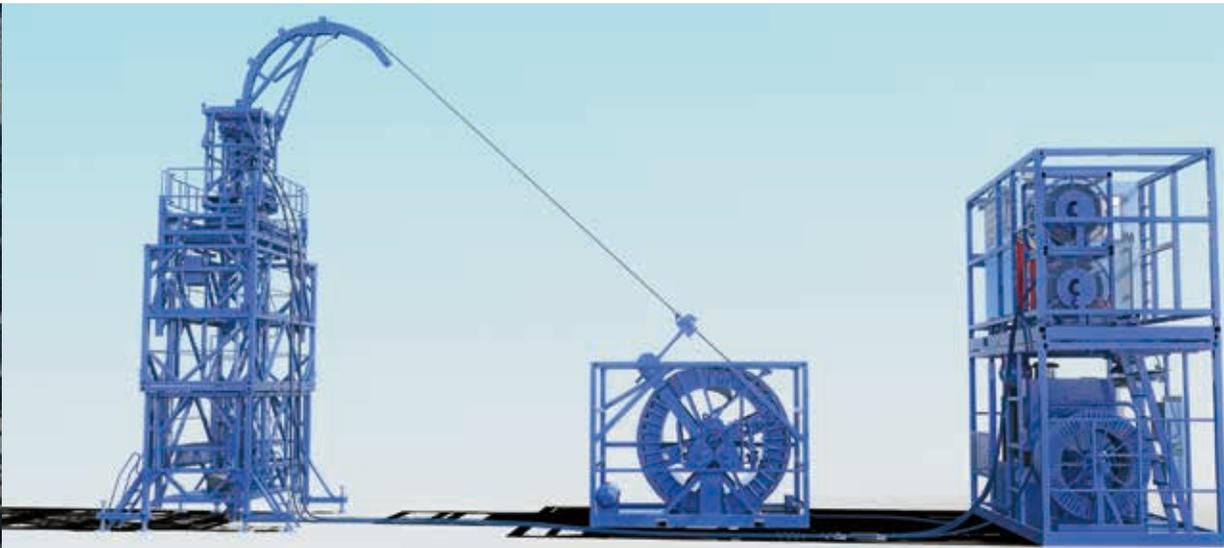
• Truck-mounted Coiled Tubing Unit

Technical Parameters of Truck-mounted Coiled Tubing Unit

Model	LG360/50	LG360/50	LG360/60	LG450/50	LG450/50
Maximum tensile strength of injector head (kN)	360	360	360	450	450
Maximum speed of injector head (m/min)	60	60	60	50	50
Maximum reel capacity (m)	4500	5000	2500	6000	6000
Matching coiled tubing (mm×m)	50×4500	50×4900	60×2500	50×6000	50×6000
Maximum pressure of blowout prevention system: (MPa)	70	105	70	70	105
Type	Two-truck mounted (sunken)	Two-truck mounted (sunken)	Two-truck mounted (sunken)	Two-truck (sunken) one-skid mounted	Two-truck mounted (sunken)

2.1.2 Skid-mounted Coiled Tubing Unit

The skid-mounted coiled tubing unit consists of 4 skids in general and is used mainly in regions such as offshore oil platforms or beach areas where transportation is not frequent. With the skid-mounted coiled tubing unit, the site layout is flexible; when the site is limited, the control skid can be mounted on the power skid. The skid-mounted coiled tubing unit can also be used in land operations. The skid-mounted coiled tubing unit has been applied in CNOOC, Jidong Oilfield, GWDC, Changqing Oilfield and Southwest Oil and Gas Field.



● Skid-mounted Coiled Tubing Unit

Technical Parameters of Skid-mounted Coiled Tubing Unit

Model	LG30/10Q	LG50/19Q	LG70/25Q	LG270/38Q	LG360/45Q	LG360/50Q
Maximum tensile strength of injector head (kN)	30	50	70	270	360	360
Maximum speed of injector head (m/min)	40	40	40	60	60	60
Maximum reel capacity (m)	3500	3500	3000	5000	5500	4200
Matching coiled tubing (mm × m)	9.5 × 3500	19 × 3500	25 × 2500	38 × 5000	45 × 5000	50 × 4200
Maximum pressure of blowout prevention system: (MPa)	35	35	35	70	70	70

2.1.3 Trailer Type Coiled Tubing Unit

The trailer type coiled tubing unit is used mainly in regions with good road transport conditions. Because of no drive shaft to the rear axle, the reel can be sunken conveniently, and the capacity is relatively large. The trailer type coiled tubing unit is used in large-capacity large pipe diameter coiled tubing operations. The trailer type coiled tubing unit includes one trailer type and one trailer and one truck type. In addition, the trailer type coiled tubing unit can be divided into single power type and combined power type in terms of the power from the tractor or not.



•• Trailer Type Coiled Tubing Unit

Technical Parameters of Trailer Type Coiled Tubing Unit

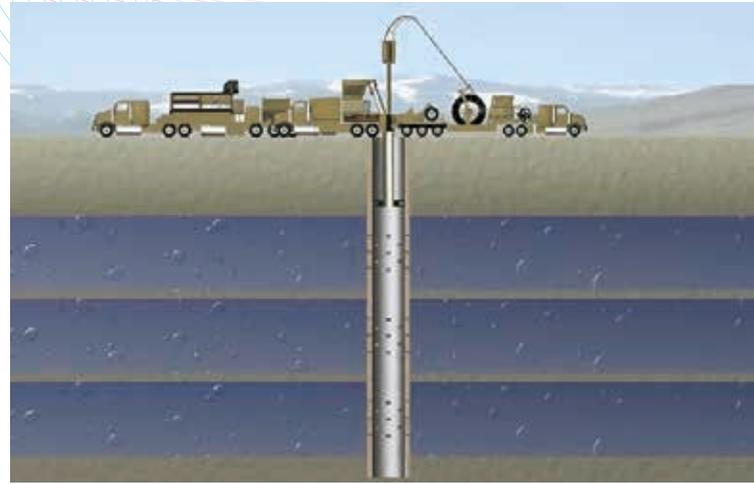
Model	LG270/32T	LG360/45T	LG360/50T	LG450/50T	LG360/60T	LG450/60T
Maximum tensile strength of injector head (kN)	270	270	360	450	360	450
Maximum speed of injector head (m/min)	60	60	60	50	60	50
Maximum reel capacity (m)	7000	55000	5000	5000	4500	4200
Matching coiled tubing (mm × m)	32 × 7000	45 × 5500	50 × 5000	50 × 5000	60 × 4500	60 × 4200
Maximum pressure of blowout prevention system: (MPa)	70	70	70	70	70	70
Type	One trailer	One trailer	One trailer and one truck	One trailer	One trailer and one truck	One trailer and one truck

2.2

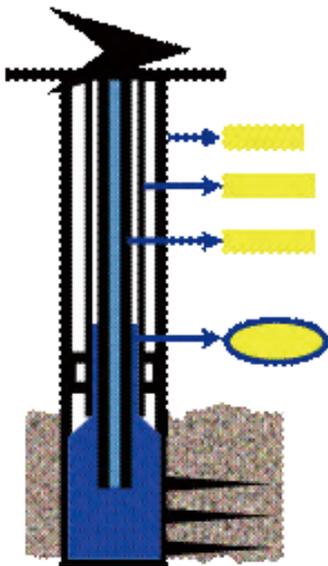
Main components

2.2.1 Coiled Tubing

Coiled tubing is also called flexible tubing or coil pipe and enwound on a reel. The maximum length of coiled tubing can reach 10000m, and the tubing body has no screwed joint. Coiled tubing is new oil and gas pipe which can be deformed plastically repeatedly and reused. Coiled tubing is manufactured using special microalloy materials and unique manufacturing technologies and is a typical high end oil and gas pipe with high technical level and high added value. Coiled tubing can achieve functions which cannot be achieved by many traditional tubular products and is one of hotspot technologies in the current world petroleum industry.



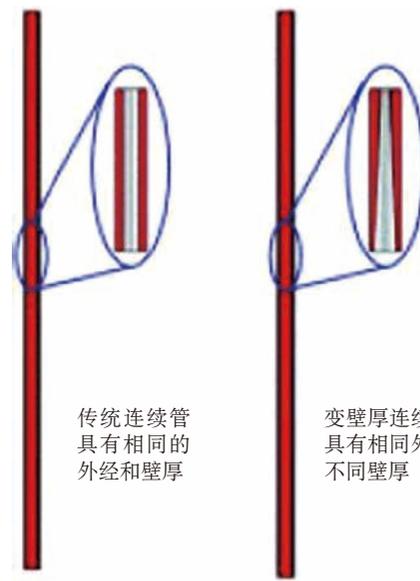
•• Work string



•• Coiled velocity string



•• Coiled line pipe



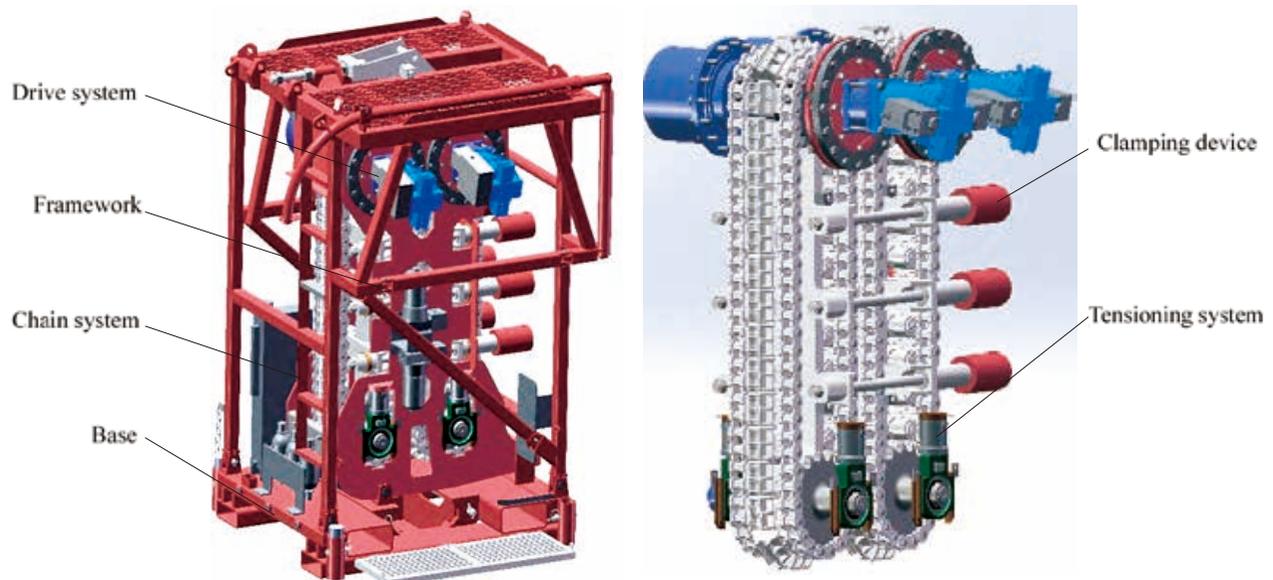
传统连续管
具有相同的
外径和壁厚

变壁厚连续管
具有相同外径
不同壁厚

•• Variable-wall thickness coiled tubing

2.2.2 Injector Head

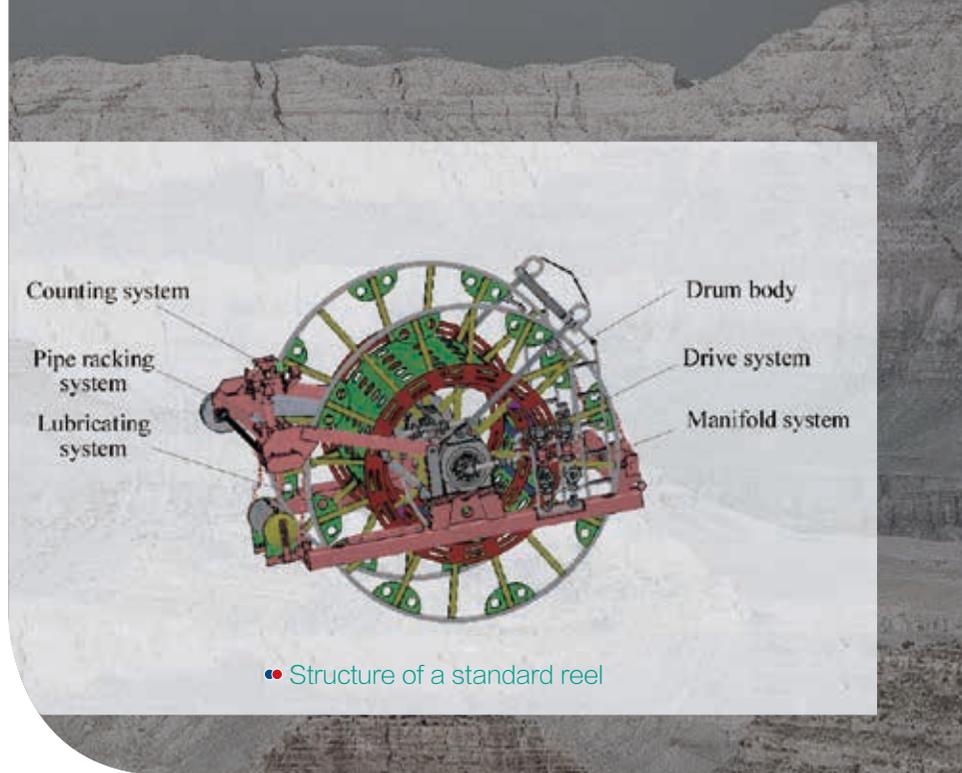
The injector head is one of key components of the coiled tubing unit and is used to mainly lift and run coiled tubing during operations. The injector head consists of mainly drive system, frame, chain system, pedestal, clamping device, tensioning system, etc.



• Injector head

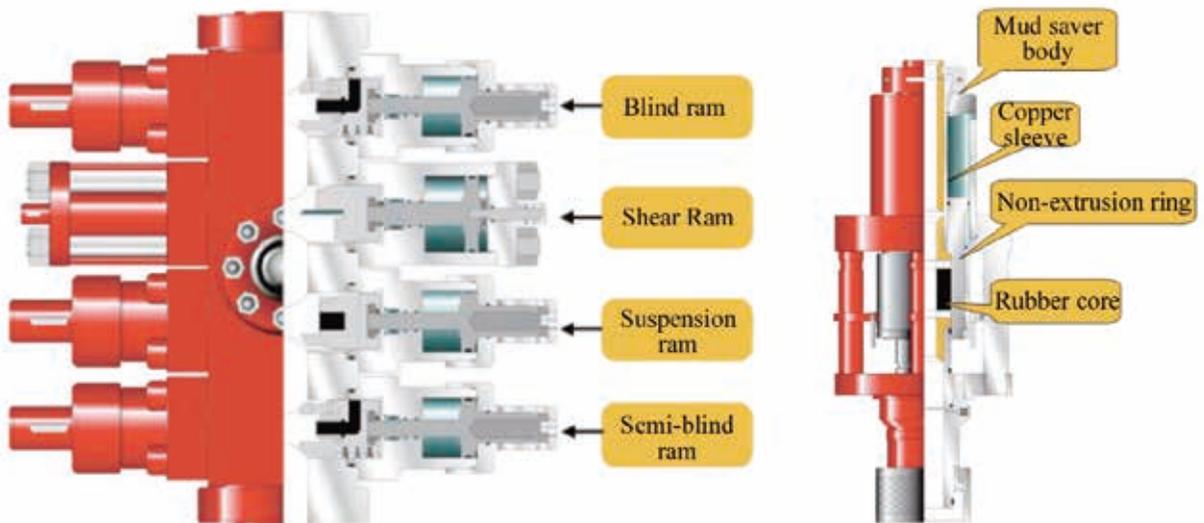
2.2.3 Reel

The reel is one of important components of the coiled tubing unit. The reel consists of mainly reel body, drive system, manifold system, counting system, pipe racking system, lubricating system, etc. and directly decides the transport dimension of the coiled tubing unit and its coiled tubing winding capacity.



2.2.4 Blowout Prevention System

The blowout prevention system mainly includes BOP, blowout box and lubricator. As the well control equipment of oil and gas wells, the blowout prevention system functions mainly in sealing the pressure in wells and preventing blowout accidents etc. during field operations with the coiled tubing unit.



• Blowout prevention system



• Tower

2.2.5 Auxiliary Equipment

The outfitted auxiliary equipment includes truck crane, tower, tubing handler, guide-in device, welding device, nondestructive testing device, etc. centering on “professional coiled tubing services” .



• Vehicle lifter



Rugged computer Signal converter Ellipticity detection device Defect detection device

• Nondestructive testing device



• Tubing handler

3 Typical Cases

3.1

Hydraulic and Mechanical Cutting Technology for Downhole Tubing – Complex Operating Conditions, Difficult Problem Solution

Well Y5650 of Qinghai oilfield is a water injection well. Due to sand production, the string in the well was buried by sands and it was needed to cut the tubing above the sticking point and then to recover the water injection function of the well through heavy repair. The tubing at 1190m was successfully cut using the coiled tubing unit and hydraulic and mechanical cutting technology.



• Hydraulic cutting of downhole tubing in Qinghai oilfield

3.2

Coiled Tubing Drilling and Milling Technology – Reef Drilling and Milling, Ranking First

Totally 7 coiled tubing units of CNPC Drilling Research Institute and other 4 manufactures competed on JY15 and JY30 platforms. The average plug drilling time of the coiled tubing unit of CNPC Drilling Research Institute was 5055min/plug, and that of other manufacturers 50~55min/plug, and that of other coiled tubing units 65min/plug. The drilling and milling speed of the coiled tubing unit of CNPC Drilling Research Institute ranked first. The overall quality and high stability of the coiled tubing unit of the Drilling Research Institute have been praised and recognized by customers.



• Drilling and milling construction site with LG360/50 coiled tubing unit

3.3

Integrated Quick Commissioning Technology – One Coiled Tubing Unit = 4 Workover Rigs

LG180/38 integrated coiled tubing unit has been applied in quick commissioning of 459 wells in Qinghai oilfield. The construction time with LG180/38 is 30-35 hours less than that with conventional coiled tubing units. The highest efficiency of a single coiled tubing unit is 3 wells-times per day, thereby greatly reducing downhole labor intensity and operation cost under severe plateau environment conditions.



• Integrated construction operation site with LG180/38 coiled tubing unit

3.4

Velocity String Technology – Clever Treatment of Accumulated Liquid, Flow Regime Change



LG180/38 coiled tubing unit with H070 ϕ 38.1mm \times 3.18mm has been applied in drainage and gas production in the three-low gas field, and the cumulative increased production is over 1.0 bcm. The problem on accumulated liquid in the gas field has been solved.

- Velocity string construction site with LG180/38 coiled tubing unit

3.5

Application of Domestic Coiled Tubing with High Steel Grade in Shale Gas – Independent Innovation, Difficult Problem Solution

CT110 50.8mm \times 4.44mm 4800m coiled tubing was successfully applied in downhole operation of H4 platform well in Changning, Sichuan, thus filling up the gap of application of domestic coiled tubing with high steel grade in the shale gas exploration and development field.



- Application of domestic coiled tubing with high steel grade in shale gas exploration and development

3.6

Overseas Applications – Going abroad, Receiving Good Comments

The coiled tubing units of CNPC have been applied in foreign countries such as Indonesia, Iraq, Venezuela, etc.

They were used in well HF052-M052D1 to complete induced flowing by substituting diesel oil, in well HF069-M258 to complete gas lift drainage operation, and in well HF002-M325 to complete cleanout operation, and the maximum running depth was over 3600m. During operations in the wells, the skid-mounted coiled tubing unit ran stably and had a low fault rate.



• Construction site with LG270/38Q coiled tubing unit in Indonesia

4 R&D Equipment

The coiled tubing unit laboratory of CNPC Drilling Research Institute aims at the development trend of the world coiled tubing technology and equipment, makes a study of the fundamental theory and experimental method of coiled tubing technology and equipment, and solves the major technical bottlenecks in CNPC' s domestic and foreign exploration and development operations. In addition, the laboratory is intended to develop reserve technologies, frontier technologies and high and new technologies on the basis of laying stress on independent innovation and originality, and provides powerful support to mid-term and long-term development of CNPC and increase in independent innovation capacity.



• Coiled tubing unit simulator



• Test base of CNPC DRI—coiled tubing unit laboratory



•• Coiled tubing unit simulation test



•• Special-purpose test well site for commissioning of coiled tubing unit



•• Professional equipment commissioning and field service team

5 Qualifications and Standards

DRI has multiple qualifications and certificates. **4** industrial standards have been formed and DRI has over **50** patents and has obtained multiple prizes.

5.1

Qualifications

5.1.1 API 质量体系认证



5.1.2 CCS, National Explosion-proof Certification, Quality System Certification and API Quality System Certification



5.1.3 National Manufacture License of Special Vehicles



5.2

Standards

Took charge of preparing 3 industrial standards and 1 company' s standard

Standard No.	Standard name
Q/CNPC-BG1023-2010	Specification for Coiled Tubing
SY/T 6698-2007	Recommended Practice for Coiled Tubing Operations in Oil and Gas Well Services
SY/T 6700-2007	Coiled Line Pipe
SY/T 6761-2014	Coiled Tubing Unit
Q/SY02008-2016	Use and Maintenance of Coiled Tubing Unit
GB/T 34204-2017	Coiled Tubing

5.3

Patents

11 invention patents and 28 utility model patents were obtained in the R&D process of the coiled tubing unit product. 9 invention patents and 10 utility model patents were obtained in the R&D process of coiled tubing manufacturing technology and product.

Main Patents of Coiled Tubing Unit & Technology

No.	Achievement name	Name of intellectual property rights	Documentation No.
1	A coiled tubing guide device	Patent of invention	ZL 2011 1 0108451.3
2	A preparation method for coiled tubing injector head fixture block with friction increasing coating	Patent of invention	ZL 2010 1 0535928.1
3	A simulation loading device for coiled tubing injector head test	Invention patent right	ZL 2012 1 0560106.8
4	A coiled tubing injector head driving device	Invention patent right	ZL 2012 1 0209086.X
5	A tubing racking converter and control system for coiled tubing unit	Invention patent right	ZL 2012 1 0378875.6
6	An automatic coiled tubing racking device	Utility model patent	ZL 2012 2 0402449.7
7	A fixture block	Utility model patent	ZL 2012 2 0389721.2
8	A coiled tubing injector head	Patent of invention	ZL 2012 2 0383918.5
9	A chain tensioner	Utility model patent	ZL 2012 2 0388877.9
10	A fixing structure of quickly replaceable fixture block for coiled tubing injector head	Utility model patent	ZL 2012 2 0307558.0

5.4.1 Grade I science and technology advance prize of CNPC



5.4

Prizes

5.4.1 Grade I science and technology advance prize of CNPC

The project “Coiled Tubing Stimulation Technology and Auxiliary Tools” was awarded with grade I science & technology advance prize of CNPC.



5.4.3 cippe product innovation gold prize

LG360/50 coiled tubing unit was awarded with CIPPE 2014 innovation gold prize.



5.4.2 Grade I national energy science and technology advance prize

The project “Coiled Tubing Unit & Technology” was awarded with grade I national energy science and technology advance prize.



5.4.4 Ten major powerful engineering tools in the “twelfth five-year plan” period

LG360/60T coiled tubing unit - one of top ten powerful engineering tools in the “12th five-year plan” period



6 Expert Team



Su Yinao

Oil and gas drilling engineering expert, Academician of the Chinese Engineering Academy. He has long been engaged in the study and application of drilling engineering technologies and has multiple innovative achievements in the study of drilling mechanics, trajectory control and downhole tools.

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He Huiqun

Doctor, professor level senior engineer, candidate of talents for “National Millions of Talent Project”, expert enjoying the “government special allowance from the State Council” .

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Liu Shoujun

Doctor, professor level senior engineer, senior technical expert of CNPC. He has long been engaged in the study of oilfield drilling and workover equipment. He has made a significant contribution to coiled tubing technology and equipment development, coiled tubing equipment test systems, and training of coiled tubing operation personnel.

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Cao Heping

Senior engineer, institute level expert. He has long been engaged in R&D of coiled tubing technologies and units. He is the first person in charge of research on coiled tubing units in China.

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Xiong Ge

Senior engineer, institute level expert. He has long been engaged in the study of oilfield drilling and workover equipment. He successively took charge of the study of LZ73/580T coiled tubing unit, LG60/360T coiled tubing unit, CT38 coiled tubing unit, matching tools for downhole operation technologies with coiled tubing, etc.

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Zhang Sanpo

Engineer. He has long been engaged in manufacturing of coiled tubing units. He successively participated in the study and manufacturing of key equipment such as LZ73/580T coiled tubing unit, LG60/360T coiled tubing unit, CT38 coiled tubing unit, etc.

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Zhou Zhongcheng

Engineer. He has long been engaged in the study of coiled tubing units. He successively took charge of the study and market popularization of key equipment such as small diameter pipe drainage and gas recovery unit, skid-mounted coiled tubing unit, special tubing operation unit, etc.

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7 Service and Training

7.1

Training

CNPC has professional training and service teams and works out relevant training plans according to different needs of users. CNPC can provide one-package services including simulation training in the test room and field training, and the training contents include machinery, electricity, hydraulic systems, etc. A coiled tubing unit simulation system has been designed and manufactured. Combining software with hardware, the system can be used to simulate various functions and

actions of the coiled tubing unit, realize loading, simulate actual drilling operation conditions and train actual operating personnel visually. After training, a professional knowledge exam is performed to determine the qualification of trainees. There are multiple service means, including explanation at assembling sites, demonstration at operation sites, simulation system demonstration, etc., for convenience of understanding and remembrance.



● Photo of the first batch of trainees



• Workshop training



• Simulation well training

Trained the coiled tubing unit operators of CNPC for certification, cultivated a large number of excellent coiled tubing unit operators for CNPC, improved their quality, promoted the improvement of site construction operation level, and established a substantial foundation for qualification management of coiled tubing operation teams of CNPC



• Operator training certificate



The coiled tubing unit operation training center is the only large coiled tubing unit indoor training center in Asia, which can be used to vividly simulate outdoor site operating conditions and greatly shorten the training period

•• Coiled tubing unit operation training center

The coiled tubing unit simulator is used in training; according to operating requirements in China, the software has been continuously upgraded and optimized.

CNPC has established a perfect after-sales service system and professional technical personnel who have much knowledge in machinery, electricity and liquid and are “on-call” round the clock. CNPC can provide remote technical support and diagnosis and solve product problems effectively in time.



•• Application of coiled tubing unit simulator



7.2

After-sales



• Operation site with coiled tubing unit

Perfect and illustrated manual of accessories have been prepared; detailed maintenance manuals and menus have been provided; experienced maintenance personnel and design personnel have been provided for round-the-clock support. Repair and re-validate the components needing heavy repair as per the manufacturer's original standard to ensure their quality, extend their service life and reduce the customer's use cost.

7.3

Service contact

After-sales service contact: Wan Dongdong

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