

Coiled Tubing Unit

Science & Technology Management Department

2013



CHINA NATIONAL PETROLEUM CORPORATION

*Coiled Tubing Unit, A Universal Machine in
Oil and Gas Development!*



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China National Petroleum Corporation (CNPC) is a state-authorized investment agency and a state holding company. On July 1998, with the implementation of the Institutional reform of the State Council, CNPC was reorganized to become an integrated oil company of cross-regions, cross-industries and cross-countries, it adopts modern enterprise system to realize the integrations of upstream and downstream operations, internal and external trade, production and marketing. CNPC's business covers six main sectors: oil and gas operations, petroleum engineering service, petroleum engineering construction, petroleum equipment manufacturing, financial services and new energy development. In 2012 CNPC produced 110 million tons of crude oil and 79.82 billion cubic meters of natural gas, while crude processing volume reached 191 million tons. The total revenue of RMB 2,690 billion with a profit of RMB139.1 billion had been achieved the same year.

CNPC was ranked 4th among the world's largest 50 oil companies and 6th in Fortune Global 500 in 2012.

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.

Coiled Tubing Unit is one of representatives for major innovations of CNPC.

CLEAN ENERGY SUPPLY FOR BETTER ENVIRONMENT

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 petroleum 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 1000 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, under-balanced drilling, old well deepening, sidetracking of horizontal wells, etc. in terms of drilling.

INTRODUCTION



Bohai Oilfield



Jidong Oilfield



Changqing Oilfield



Dagang Oilfield



Jiangnan Oilfield



Liaohe Oilfield



Southwest Oil and Gas Field

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COILED TUBING UNIT

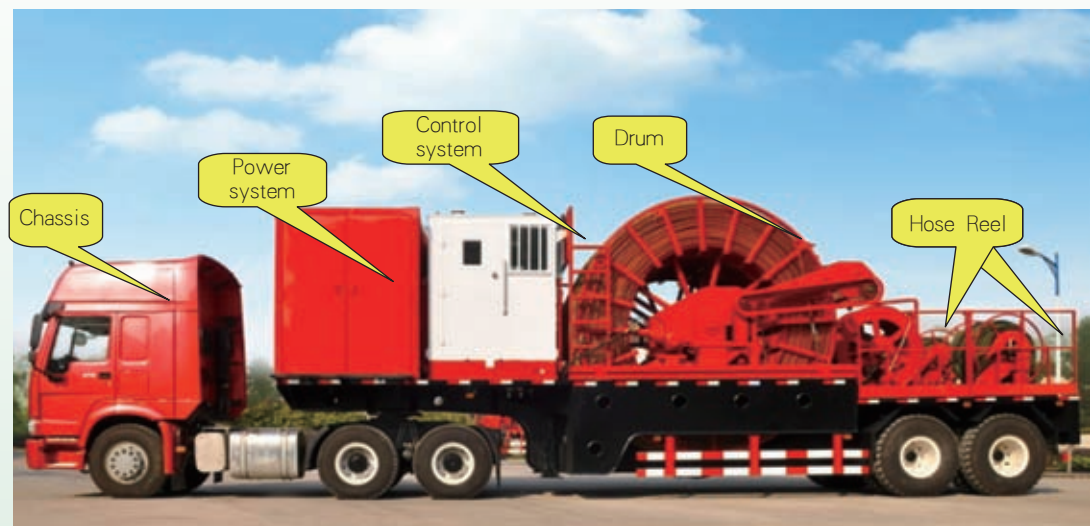
The coiled tubing unit can run thousands of meters of continuous joint-free steel pipes (diameter 9~88.9mm) into the production tubing of an oil and gas well to complete specific workover operations such as well cleanout, fishing, fracturing, acidification, etc. or into its casing for logging operations or direct drilling operations. The coiled tubing pulled out of the well is directly wound onto the large diameter reel for convenience of transportation. Compared with conventional threaded tubing, the coiled tubing has more advantages, saves tubing tripping time and eliminates the hard work for make-up and break-out of singles in terms of both operation and oil production. The coiled tubing can be used to circulate workover fluid downhole continuously and replace and fill workover fluid downhole at fixed points quantitatively, thus reducing reservoir damage and ensuring operation safety. Compared with conventional technologies, the coiled tubing technology is practical technically and economically and has higher operation efficiency. The coiled tubing technology has been widely applied in the fields involving drilling, completion, well logging, oil production, workover,

gathering and transportation, etc.

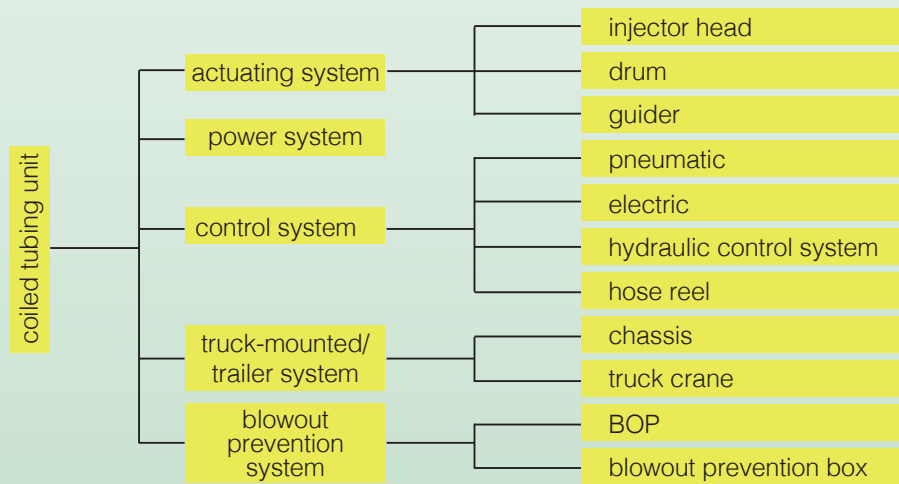
In the 1980s, CNPC began to track, study and develop the coiled tubing unit. At present, CNPC has a large number of excellent scientific research and development talents, professional manufacturers; perfect after-sales service systems and professional service teams. In addition, CNPC has built up China's 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.

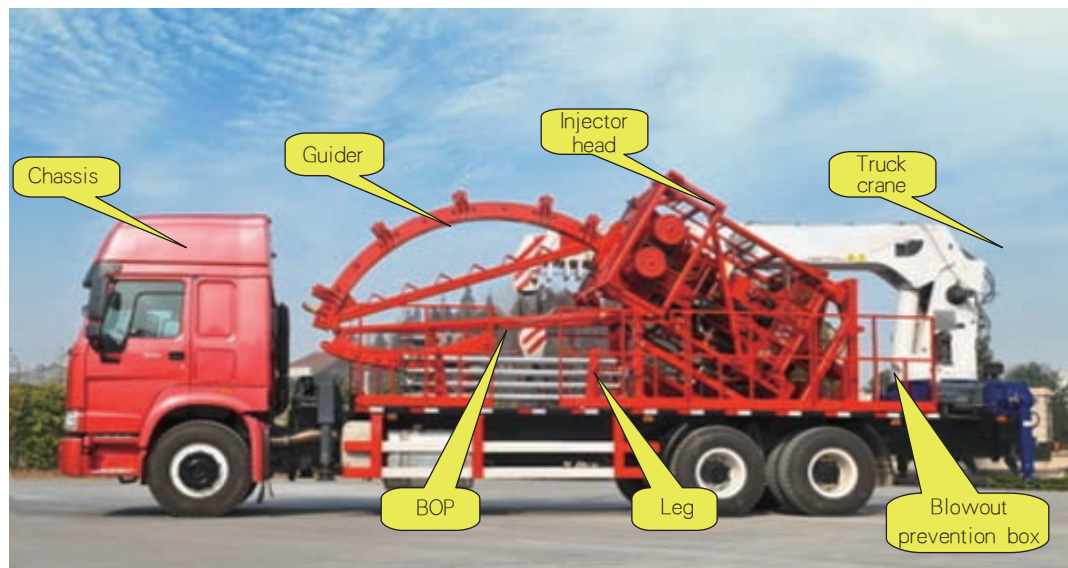
CNPC can study and develop series products of multiple models and multiple specifications, including multiple transportation modes such as truck-mounted, skid-mounted, trailer-mounted and mixed ones, etc. The diameter of coiled tubing ranges from 9mm to 73mm, length from 3500m to 5000m and its max lifting force from 2.5KN to 580KN. 8 patent technologies have been formed. CNPC has obtained the special vehicle manufacturing qualification by China National Development and Reform Commission and formulated the industrial standard Coiled Tubing Unit (SYT6761-2009).

The coiled tubing unit generally consists of actuating system mechanism (injector head, drum, guider), power system, control system (pneumatic, electric and hydraulic control system and hose reel), truck-mounted/trailer system (chassis and truck crane), blowout prevention system (BOP and blowout prevention box, etc.).



Structure composition of the main truck of the two-truck mounted coiled tubing unit





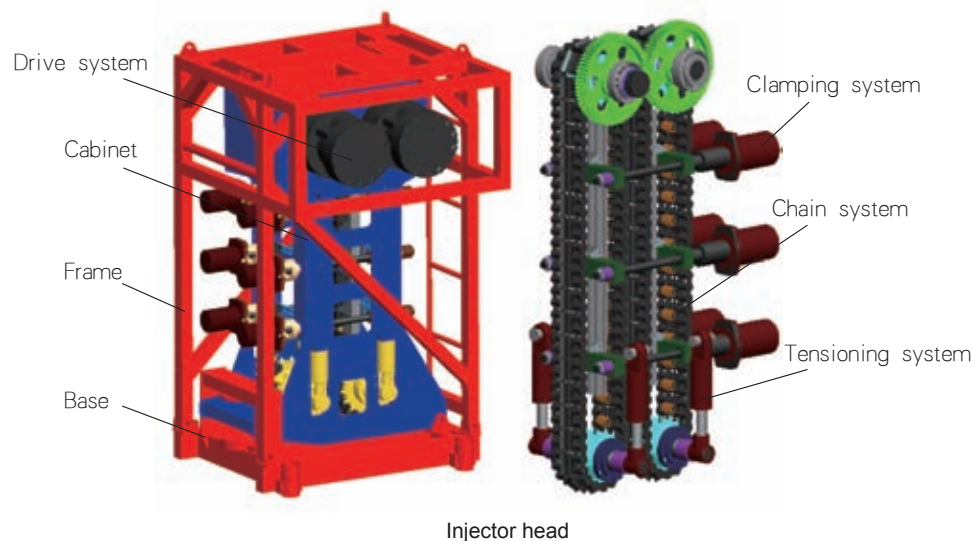
Structure composition of the auxiliary truck of the two-truck mounted coiled tubing unit

2.1 Executive System

2.1.1 Injector Head

The injector head is one of key components of the coiled tubing unit and is mainly used to lift and run coiled tubing during operations. The injector head

consists of mainly drive system, cabinet, frame, base, clamping system, chain system, tensioning system, test system, protective system, etc.



When the injector head works, two synchronous hydraulic motors that can run positively and reversely drive the chain and the fixture block to clamp the coiled tubing for moving up and down, and the chain is fixed with the fixture block together to adapt to

the OD of the coiled tubing string. The 6 hydraulic cylinders of the injector head tightly press the chain via the push plate so as to generate the friction force needed to lift and run coiled tubing.

Injector head product series

Model	Max lifting capacity (t)	Maximum injection force (t)	Max lowering speed (m/min)	Applicable pipe diameter
(in)	580	290	35	3500
ZR30	30	15	60	3/8~1/2
ZR50	50	25	60	3/8~1/2
ZR90	90	45	60	3/8~1
ZR180	180	90	60	1~ 1-3/4
ZR270	270	135	60	1~ 2
ZR360	360	180	55	1~ 2-3/8
ZR450	450	225	55	1~ 2-7/8
ZR580	580	290	45	1~ 3-1/2

2.1.2 Guider

The guider’s functions in leading coiled tubing to enter and exit out of the injector head depend upon the bent arc structure. The guider is generally designed into fold type, for convenience of transportation. The guider is installed on the frame

of the injector head via the support lever or the hydraulic cylinder support.

The specifications of the guider mainly include 72in, 90in, 96in and 110in (drilling rig).



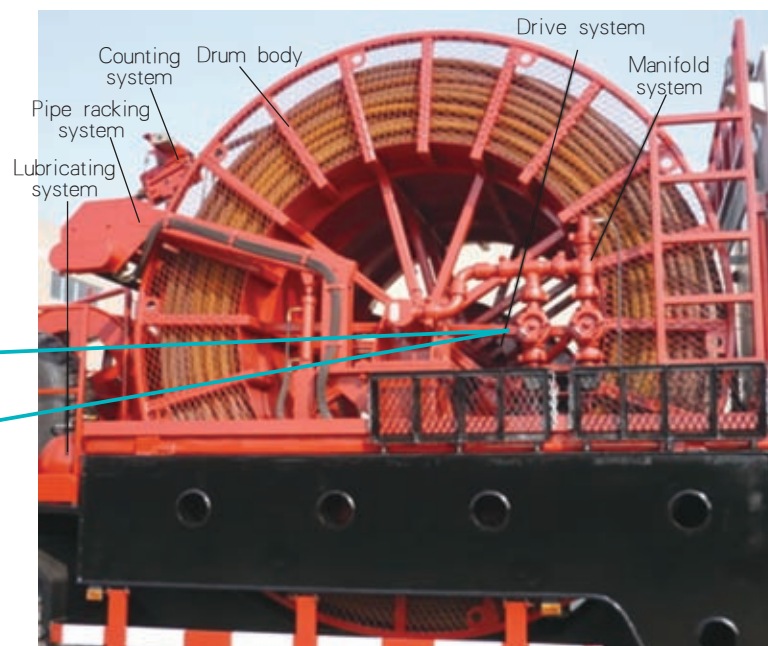
110in guider schematic

2.1.3 Drum

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



Manifold system



Drum

Drum product series

Model No.	CZ135	CZ250	QZ250	TG345	TG435
Drum body size (mm)					
ID	1830	2030	1830	2350	2600
OD	2880	3350	3020	3750	4200
Inner width	1660	1720	1720	2450	2450
Tubing winding capacity (m)					
1-1/4	5500	9600	7000		
1-1/2	3500	5000	5000		
1-3/4		4200	3800	7800	
2		3200	2900	6000	7100
2-3/8				4500	5200
2-7/8				2800	3500
3-1/2					2000
Working pressure (MPa)					
	70/105	70/105	70/105	70	70

2.2 Power System

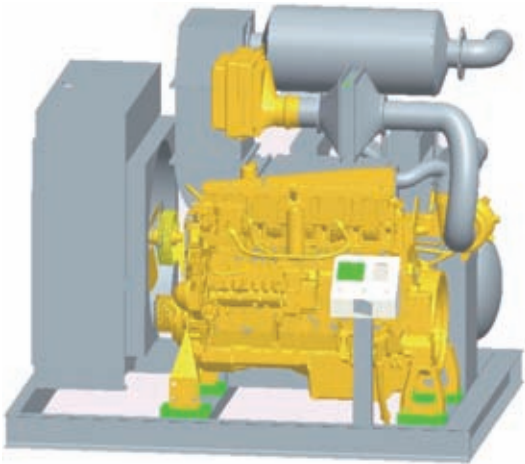
The power system mainly consists of engine, transfer case, hydraulic oil tank, accumulator, radiator, etc. and has the functions of providing power to the coiled tubing unit.



Accumulator



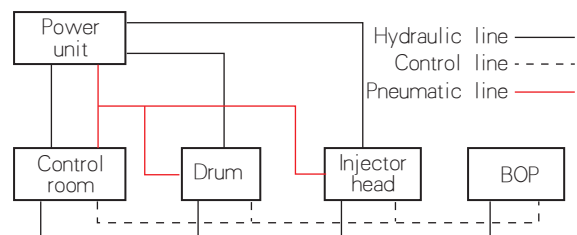
Transfer case



Engine

2.3 Control System

The control system consists of hydraulic system, pneumatic control system, and electric control system and control room. The hydraulic control system is composed of three control loops, which control the running of injector head, drum and each control element respectively. The hydraulic system mainly controls the action and running of the coiled tubing unit.



Control system schematic

2.4 Truck-mounted/Trailer System

The chassis consists of main truck and auxiliary truck; the main truck consists of tractor and semi-trailer, and the auxiliary truck consists of chassis truck and truck crane. The integral design can meet the requirements of special vehicles in oilfields as well as complex road conditions and field operations.



Main truck



Tractor



Semi-trailer



Auxiliary truck

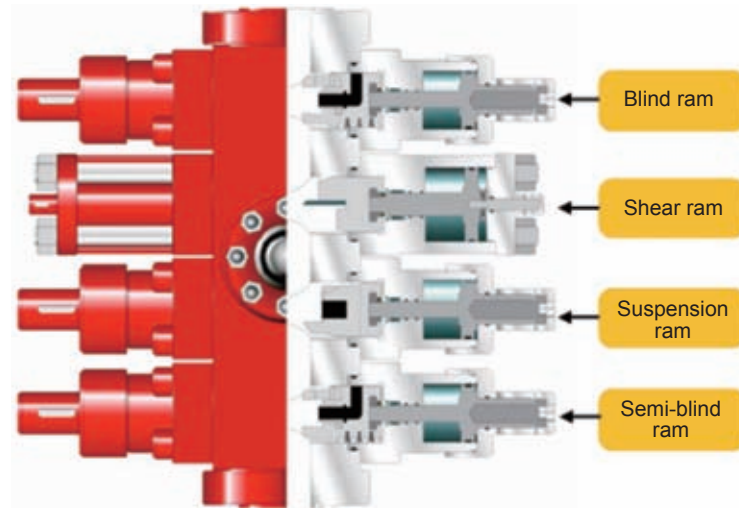
Main performance parameters of the tractor:
 Model: ZZ4257N3247C1/S2WA-5
 Drive mode: 6×4
 Unladen mass (kg): 9210
 Total mass (kg): 49000 (in full load state, including tractor and semi-trailer)
 Outside dimension (mm): 6800×2496×3668
 Axle base/ rear overhang (mm): 3225+1350/725
 Wheels tread (mm): Front 2022/ rear 1830
 Approach angle (°)/ departure angle (°): 16/70
 Maximum traction mass (kg): 40000

Main performance parameters of the semi-trailer:
 Model: WS9550
 External dimension: 11280×3300×1750
 Maximum total load bearing capacity (kg): 40000
 Unladen mass (kg): 15000
 Minimum road clearance (mm): 400
 Axle base (mm): 7611+1350
 Wheels tread (mm): 2240
 Angle of departure (°): 35

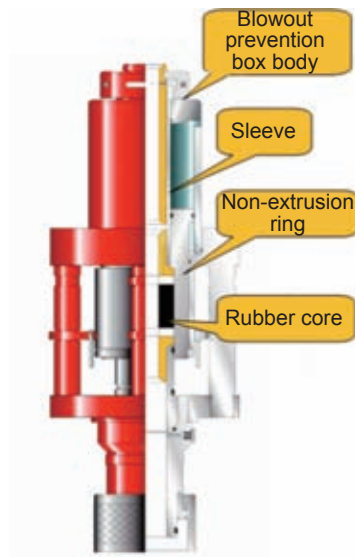
2.5 Blowout Prevention System

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.



BOP



Blowout prevention box



Lubrica

2.6 Main Models and Technical Parameters of Coiled Tubing Units

Coiled tubing unit model	Max hoisting capacity of injector head KN	Max injection force of injector head KN	Max lifting speed m/min	Drum capacity m	Applicable max diameter of coiled tubing mm	Working pressure of BOP MPa	Working pressure of blowout prevention box MPa
LZ580/73T	580	290	35	3500	73	70	70
LG360/60T	360	180	45	4500	60.3	70	70
LG360/60F	360	180	60	2300	60.3	70	70
LG360/50	360	180	60	4200	50.8	70	70
LG270/38Q	270	135	60	5000	50.8	70	70
LG180/38	180	90	60	3500	38.1	70	70
LG70/25	70	20	30	2500	25.4	70	20
LG50/19Q	50	15	40	4000	19.05	70	20

2.7 Technical Characteristics of the Coiled Tubing Unit

Compared with other similar products, the coiled tubing unit of CNPC has the following characteristics and advantages:

1. Complete matching components as per, the integral design, compact structure, uniform load distribution, convenient field operation, and meeting the requirements of transportation conditions.

2. Injector head specifications are complete and can meet the requirements of various coiled tubing operating conditions.

3. Drum specifications are complete; the drum can be sunk according to transportation conditions and the coiled tubing of different outer diameters can be rapidly changed. The drum speed can be continuously adjusted; coiled tubing is arranged uniformly and orderly; the inner and outer manifolds can resist high pressure up to 105MPa. Various sensors involving pressure, flow rate, length measurement, etc. are set up.

4. The power and control system use the integrated mechanical-electric-hydraulic control technology, so that the injector head can coordinate with the drum. The coiled tubing unit automatically keeps a constant

tensioning force during lifting and lowering of coiled tubing; the feed liquid pump of the pump uses a variable pump with constant pressure output, so that the drum works automatically with the speed and direction of the injector head while providing a continuously constant tensioning force. When the downhole coiled tubing drives the injector head motor to work, it can stably work without impaction and intermission via the balance liquid way; the main hydraulic components, control valves and instruments all use the products of international top-level famous brands.

5. Integral unit operation, control and operation parameter display and records are concentrated in the control room. Instruments, meters and operation control components are installed and arranged on the console panel by areas and blocks, thus making for quick and convenient operation and parameter reading.

6. The designed telescopic legs can meet the requirements of wellheads of different heights.

7. Various coiled tubing handlers are provided, which can conveniently realize rearrangement and replacement of coiled tubing between different drums.

8. Coiled tubing guide devices of various specifications are provided, thus solving the difficult problem about leading coiled tubing into the injector head.

3

APPLICATION
CASES

3.1 Sand Washing and Plugging Removal

The geologic structure of well XH1 in Dagang oilfield is located in north Dagang block in Huanghua depression. The vertical section length of the well is 838m, the maximum measured depth 1546.89m, the maximum vertical depth 1168.97m, the maximum horizontal displacement 523.57m, the horizontal section length 246.89m, the maximum dogleg severity 9.29°/30m, and the maximum closure azimuth 22°/10m. Sand plugging was serious and

lost circulation occurred in this well. After plugging removal failure with conventional methods, LG180/38 coiled tubing unit was used in plugging removal; coiled tubing favorably entered the screen in the horizontal section and leakage stoppage operations while sand washing were carried out; after 3 hours of operations, the sand washing and plugging removal work was completed. After this job, the daily oil production of the well is 9.4t, which is 3.3t higher than that (6.1t/d) before sand washing and plugging removal; therefore, a remarkable effect has been obtained.



Sand washing and plugging removal operations in well H1 in Dagang Oilfield

3.2 Annular Sand Fracturing Process

Dual-layer hydraulic-jetting annular sand fracturing operations with LG360/60T coiled tubing unit with homemade coiled tubing in well Y72-24-38 in Liaohe oilfield were successfully performed from Sept. 24 to Sept. 28, 2011.



Hydraulic jet sand fracturing operations in well R72-24-38 in Liaohe oilfield

3.3 Drilling Operation Process

LG360/60T coiled tubing unit in cooperation with pump set, solid control system and well control system was used in drilling operations of well M758C in Liaohe oilfield on Nov. 24, 2011, and the drilling speed reached 10m/h at -20°C .



Downhole tools



Drilling Operations in Liaohe Oilfield

3.4 Hydraulic and Mechanical Cutting Process for Downhole Tubing

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

4 R&D EQUIPMENT

Coiled tubing unit R&D and production equipment is complete with excellent conditions.



CNPC drilling engineering test base—coiled tubing equipment test room



Special-purpose test well site for commissioning of equipment



Professional equipment commissioning and field service team

5 QUALIFICATIONS & STANDARDS

CNPCC has formed a number of industrial and professional specifications through many years of R&D and manufacturing and has multiple intellectual property rights.

5.1 Industrial Standard

SY/T 6761-2009 Coiled Tubing Unit

5.2 API Quality System Certification



5.3 CCS Quality System Certification



5.4 National Manufacture License of Special Vehicles



5.5 Patents

The coiled tubing unit has 9 utility model patents and 2 patents of invention.

Injector head patent

The coating of the fixture block involved in the patent has remarkable features such as resistance to wear, corrosion and oil sludge, wax prevention, anti-scaling, etc. and reaches the world's leading level.



Coiled tubing with wear coating



Injector head fixture block preparation method patent

Control system patent

The coiled tubing unit integrates a control device patent technology: the integrated coiled tubing unit control device involved in the patent can ensure that the coiled tubing unit completes various commands and complex work safely and highly effectively.



Integrated coiled tubing unit control device patent technology

Blowout prevention system patent

The coiled tubing blowout prevention box involved in the patent uses a dynamic sealing technology and has high sealing pressure, the sealing pair is resistant to wear and aging, and the blowout prevention box has high safety, reliability and practicability.



Coiled tubing blowout prevention box patent technology



Other patents of process and tools for the coiled tubing unit

The coiled tubing guide device process is a very practical patent in the coiled tubing technological field. With the patent technologies, large diameter coiled tubing is led into the injector head from the drum very easily, the working efficiency is increased by over 300%, the labor intensity of workers is reduced by 500%, and the installation cost at the equipment operation site is saved by over 20%.



Coiled tubing guide device patent



Patent of downhole agent and gas injection device hanger for small diameter tubing



Patent of downhole agent and gas injection device for coiled tubing



Patent of two-flap check valve for coiled tubing



Patent of slip connector in coiled tubing

5.6 National High-tech Product Certificate



6

EXPERT
TEAM



Su Yinao Oil and gas drilling engineering expert, Academician of the Chinese Academy of Engineering. He has long been engaging 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.
Tel.: 010-83597067
Email: suyinaodri@cnpc.com.cn



Zhong Shude Profession level senior engineer. He has long been engaging in R&D of petroleum equipment.
Tel.: 010-83593364
Email: zhongshude@cnpc.com.cn



Ma Jiaji Profession level senior engineer. He has long been engaging in R&D of petroleum equipment.
Tel.: 010-83593364
Email: majiaji@cnpc.com.cn



He Huiqun Profession level senior engineer. He is the chief expert in charge of the project “R&D of Coiled Tubing Operation Equipment and Tools” of CNPC and the leader of national “863” program subject “Coiled Tubing Technology and Equipment”.
Tel.: 0716-8121008
Email: hehq@cnpc.com.cn



Liu Shoujun Senior engineer, senior technical expert. He has long been engaging in the study of oilfield drilling and workover equipment and has made a significant contribution to the development of coiled tubing unit equipment and technology of CNOC. Several papers written by him were published, including the Development Trend of Drilling Rig Derrick Substructures in China, the Study and Application of Coiled Tubing Units, etc. He has obtained several patents.
Tel.: 0716-8121016
Email: liusj@cnpc.com.cn



Xiong Ge Senior engineer. He has long been engaging in the study of oilfield drilling and workover equipment. He has successively taken 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. He has obtained several patents.
Tel.: 0716-8115694
Email: xiongg@cnpc.com.cn



Zhang Sanpo Engineer. He has long been engaging in the R&D of oil and gas wellhead equipment in oilfields. Since 2005, he has participated in the study and manufacturing of coiled tubing operation equipment as well as the important equipment including LZ73/580T coiled tubing unit, LG60/360T coiled tubing unit, CT38 coiled tubing unit, etc. He has obtained 1 individual patent of invention and 1 cooperative utility model patent.
Tel.: 0716-8311068
Email: zhangspo@cnpc.com.cn

7

TRAININGS & SERVICES

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.



Coiled tubing unit operation training center

The only large coiled tubing unit indoor training center in Asia, which can be used to vividly simulate outdoor site operating conditions

A perfect after-sales service system has been established. CNPC has professional technical personnel integrating mechanical, electrical and hydraulic knowledge and “on-call” round the clock and can provide remote technical support and diagnosis.





联系人：刁顺 先生
电 话：86-10-5998-6059
Email: sdiao@cnpc.com.cn

Contact: Mr. Diao Shun
Tel: 86-10-5998-6059
Email: sdiao@cnpc.com.cn



