Research and Application on Slim-Hole Oil Recovery Technique in Block-LP of SINOPEC

Xiaolong Li, Wen Xiao, Bing Wang, Liping Zhou, and Huaru Xu

***Abstract*—Slim-hole oil recovery technique is increasingly used in SINOPEC and there are over 220 slim-hole wells in block-LP at the moment. Meanwhile the dimension of slim-hole brings several problems such as matching tools, eccentric wearing, lifting, separate layer recovery and so on. Through lab experiments and field application test analysis from block-LP, a mature and effective supporting technology for slim-hole well has already been summarized. Also special dimension corollary equipment is under research and development to meet the need of Slim-hole oil recovery technique, such as connecting tripping device, oil drain device, QSA packer, etc. All these special dimension devices are reliable and have been put into use and running well. All in all, through practice slim-hole oil recovery technique is cost savings in both exploration and exploitation, especially in reducing the usage of steel products. The integration of slim-hole oil recovery technique, matching process and separate layer recovery technic will provide certain guiding significance for construction site.**

***Index Terms*—Slim-hole, matching process, corollary equipment, separate layer recovery technic.**

I. Introduction

Slim-hole oil recovery technique aims at cost savings in both exploration and exploitation [1]. Consequently, the technology of slim-hole is increasingly used in SINOPEC. There are over 220 slim-hole wells in block-LP of SINOPEC at the moment [2]. With the number of slim-hole wells increasing, the problems of eccentric wearing, lifting and slicing which are caused by dimension of slim-hole are increasingly serious. To solve these problems slim techniques are studied, such as corollary equipment for slim-hole wells [3], prevention technique of eccentric wearing, technique of lifting and separate layer recovery. The integration of these studies forms a slim-hole oil recovery system, which provides guiding significance for construction site.

II. The Existing Problems of Slim-Hole Well

A. Dimension of Matching Tools

Conventional pump, casing, tubing and rod are not available in slim-hole wells because of the necked dimension, which makes it a teaser for production [4]. The 139.7mm casing is used in conventional well completion, meanwhile 73mm tubing or combination of 88.9mm+73mm tubing and combination of 25.4mm+22.2mm+19.1mm rod are assembled. However, the internal diameter of slim-hole casing is 101.6mm which makes the ordinary matching tools unavailable.

B. Eccentric Wearing

As 101.6mm casing is used in slim-hole wells, interstice between rod and tubing is so small that eccentric wearing is easy to occur. Moreover, conventional tools of eccentric wearing prevention cannot be used because of slim-hole. In this situation, cycle of pump inspection is shorten which is unfavorable for oil production.

C. Lifting

The pump in slim-hole well is smaller than traditional one so it is a challenge for wells that are high productivity.

D. Separate Layer Production

The size of packer should be reduced owing to miniature wellbore, thus key parameter of packer should be reduced as well such as wall thickness. That means technologic measures and structure parameter of packer are facing an arduous task of resistance and other mechanical strength assurance.

III. Research on Matching Process of Slim-Hole Well

Through lab experiments and field application test analysis from block-LP, a mature and effective supporting technology for slim-hole well has already been summarized. This supporting technology can meet the requirements of slim-hole well and lateral well with 101.6mm casing. For example, to satisfy the lifting requirements of slim-hole well with 1800m deep, minute tube (combination of 60.3mm heavy weight tubing and nonupset tubing), minute rod (combination of Φ22mm+Φ19mm class D rod), minute pump (Φ38mm or Φ44mm converted tubing pump) and minute coupler are practicable.

A. Research on Prevention of Eccentric Wearing

1) Application of injection molding rod for eccentric wearing prevention

Injection molding rod is fixed centralizer which is independent development. Its external diameter is 46mm and length is 120-150mm. It is suit for Φ19mm and Φ22mm sucker rod. It is installed on the two ends of the sucker rod to prevent the wornout of coupler, rod and tubing. There is

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nanometer materials of carbon fiber in the manufacturing formula in order to strengthen its abrasion resistance. Its spiral shape makes it suit for eccentric wearing prevention and scraping ability.

There are two testing wells equipped with injection molding rod currently. The average production cycle of test wells is 257d which is 122d longer than common group.

2) Tubing of non-standard wall thickness and complex resin coating

Tubing of non-standard wall thickness is 4mm bigger in internal diameter and 0.8mm thicker in thickness than 60.3mm tubing. There are 4 testing wells and the first well have been running for 785 days.

Carbon- zirconium complex resin coating is a technic aims at antiwear and antiseptic. The antiwear properties of specimen with coating is 5 times better than general tubing, also abrasion loss is reduced to half. Field applications shows its good effect. It has been running for 542 days.

B. Research on Lifting of Slim-Hole Well

1) Design of column

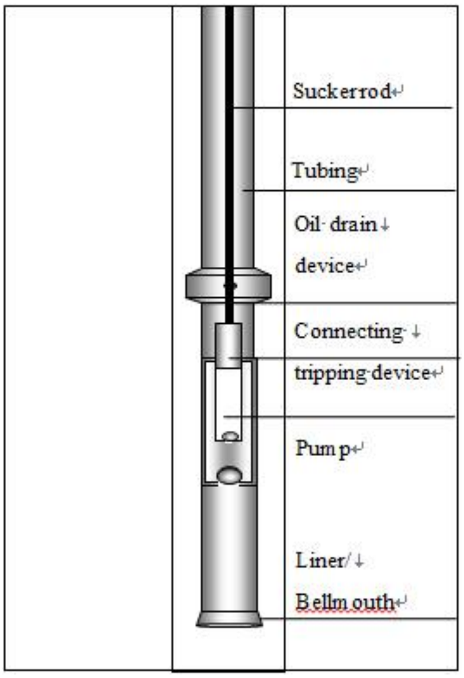

Fig. 1. Colum constitution of slim-hole well.

a) Constitution

As seen in Fig. 1, it is consisted of pump, connecting tripping device, oil drain device, sucker rod, tubing and so on.

b) Operational principle

Connect the connecting tripping device with plunger piston and the end of sucker rod, and then put them down in the well. The tubing above the pump is joint with oil drain device. When well startup, the sucker rod press downward then click into oil drain device. The well will product normally after dead space adjustment. When pump inspect or other operation, the sucker rod is picked up then connecting tripping device is squeezed the up joint of liner jacket. The compression between device and joint makes the device unlock and then take out the sucker rod. There is substantial liquid in the pipe when pick up the tubing. Press off the oil drain device with 3-5rods in order to leak the liquid in tubing.

c) Technical characteristic

Dual standing valve is equipped for sealing to insure the reliability.

The design of connecting tripping device meets the need of putting large size pump into slim-hole well. Connecting tripping device is spin type so it's reliable in docking and uncoupling and reusable.

The internal diameter of oil drain device is smaller than that of tubing thus it can be effectively sealed when taking out the rod and plunger. Even in extraordinary case, the piston of oil drain device is unfold, the device is still hermetic for piston of device will self-return by the retracing spring.

2) Design of corollary equipment

a) 56mm tubing pump for slim-hole well

As seen in Fig. 2, it consists of upper joint, liner jacket, plunger, traveling valve, standing valve, lower joint.

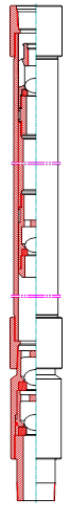

Fig. 2. Cartogram of 56mm tubing pump.

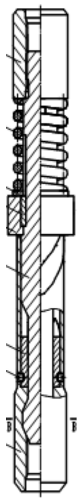

Fig. 3. Cartogram of 56mm spin type connecting tripping device.

Its principles are shown below:

When upstroke, traveling valve shuts down and pressure in pump decays. When the pressure in pump is lower than pump inlet pressure, the standing valve will unfold and liquid inflow. Meanwhile liquid outflow from the well head.

When downstroke, traveling valve unfold and pressure in pump rises. When the pressure in pump is higher than pump inlet pressure, the standing valve will shut down[5].

b) 56mm spin type connecting tripping device

As seen in Fig. 3, it consists of upper joint, core pin, trajectory, centibar, trajectory sleeve, bond, spacer, spring and lower joint.

Its principles are shown below:

When end-to-end jointing, the centibar enter the notch of upper joint through trajectory so there is only relative axial movement between the centibar and the upper joint. Trajectory sleeve is embedded in the spiral track with bond. The centibar and bond go down and push the spring to make it motivity until the centibar starts relative rotation. Under the motivity of spring the trajectory sleeve goes upward and then bond embedded in the spiral track. After that the torque is powerful enough to make a 90 degree relative rotation between the centibar and upper joint. Then the end-to-end jointing is completed [6].

Conversely, keep lifting the suck rod until there's a reversed 90 degree relative rotation between the centibar and upper joint, then the uncoupling process is completed.

C. Oil Drain Device of Compression Type

As seen in Fig. 4, it consists of upper joint, outer tube, sliding sleeve, O-ring, spring, lower joint and function part.

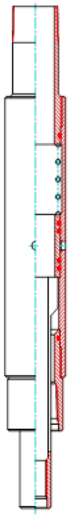

Fig. 4. Cartogram of oil drain device.

Its principles are shown below:

There is a drain hole on the outer tube and it is sealed by O-ring and sliding sleeve. The sliding sleeve is fastened by spring. Since the diameter of joint on rod is smaller than the internal diameter of sliding sleeve, the piston or rod will not touch the sliding sleeve to activate the oil drain device. When lifting the tubing in operation, drop the function part with 3-5 rods in the tubing. The function part will lay on the sliding sleeve for its bigger diameter and then underdraught the spring by gravity force of both function and rods. Then the drain hole is exposed and activated [7].

D. Separate Layer Recovery Technic of Slim-Hole Well

a) Column design of separate layer recovery

As seen in Fig. 5, the column consists of pump setting and separate layer supervisory control. The column of separate layer supervisory control is made of release tool and QSA packer. The packer parameters is shown in Table I.

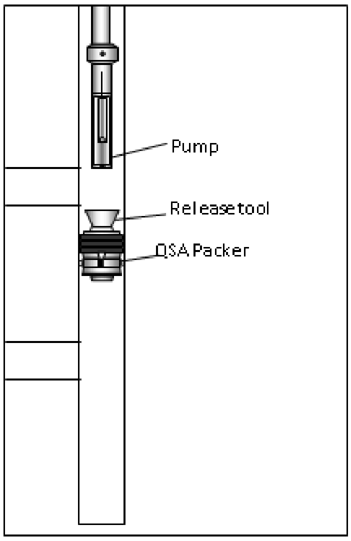

Fig. 5. Cartogram of column.

Put in the release tool to the design depth and then pressurize from tubing to activate the packer. Then the column is grappled and the confining layer is blocked. Keep pressurizing until the release tool uncoupling and then the column of separate layer supervisory control is separate with upper tubing. After lifting tubing and tripping in pump the well startup. With fishing head the packer can be inactivated by lifting to interface loading.

This technic meet the need of separate layer recovery and is reliable. Leaving the separate layer supervisory control under the pump is a good way to reduce the job throughput of pump inspection and save the application amount of tubing.

TABLE I: PARAMETERS OF PACKER

Fitness casing, mm	98.4	101.6	114.3
Outside diameter, mm	73	80	90
Length, mm	635	635	810
Setting drawdown of packer	14MPa～16MPa	14MPa～16MPa	14MPa～16MPa
Operating drawdown of packer	35MPa	35MPa	35MPa
Operating temperature	≤150℃	≤150℃	≤150℃
Unset pressure	20-40kN	20-40kN	20-40kN

b) Field application

There are 10 field test altogether and they are all successful as seen in Table II.

TABLE II: RESULT OF FIELD APPLICATION

Mode	Well Number	Before			After			*Enhanced oil per day/accumulative enhanced oil(t)*	validity (d)
		Liquid per day(t)	Oil per day(t)	Water content (%)	Liquid per day(t)	Oil per day(t)	Water content (%)		

QSA-80-35	P40-1	9.7	0.1	99.0	24.9	4.7	81.1	4.6/1693.1	730
	L104-X4	27.2	1.5	94.5	28.5	8	72.0	6.5/678.6	180
	L73-C13	39.9	0.6	98.5	23.8	3.7	84.6	3.1/241.2	95
	L63-7	12	0.5	95.8	16.4	3.9	76	3.4/490.2	93
	L95-X15	0	0		1.5	1.2	20	1.2/37.8	73
	X52-2	16	0.4	97.5	7.2	3.7	48.4	3.3/201.2	72
QSA-90 (92)-35	SHS69-X6	20.3	2	90.1	21	3.8	82	1.8/349.4	580
	LPL12-X4	23.2	1.4	94.0	12.7	5.1	60.0	3.7/1173.7	374
	L76-X25	8.5	1.5	82.4	11.9	5.5	54	4/196.6	80
QSA-73-35	S8-C298	4.1	0.7	83.0	3.8	3.3	13.2	2.6/604.5	232

IV. CONCLUSION

Injection molding rod is a solution of eccentric wearing prevention for slim-hole well and applicable for within 1200m depth wells.

Slim-hole oil recovery technique is cost savings in both exploration and exploitation, especially in reducing the usage of steel products. Corollary equipment is under research and development to meet the need of Slim-hole oil recovery technique. Connecting tripping device, oil drain device and other special dimension devices have been put into use and running well.

Compound with separate layer recovery technic is further cost saving and effective in stimulating.

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