Experimental Study on Lifting Technology of Hydraulic Driving Screw Pump

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Abstract. With the continuous development of oil fields, high gradient wells are increased year by year, highlight problem of high gradient wells is present in the low-volume oil wells. Low-volume wells in Dagang oilfield land are mainly equipped with rod pump, with serious problem of partial grinding, short production cycle, and low pump efficiency. The low-volume oil wells characterized by directional wells and horizontal wells in beach are mainly equipped with ESP, and the trajectories of the wellbore are more complex than the land. The pump flow rate is less than that of the motor shell, the temperature rise of the unit, the motor burned, the cable breakdown and other problems are prominent in ESP lift, and the production cycle is short. In view of the above problems, research on lift technology of hydraulic driving screw pump is carried out. The hollow screw is driven by the reverse circulation Power liquid, and the lifting efficiency is effectively improved. Through the test, the system can be adjusted in the range of 0.1-0.24L/s, to meet the production capacity of 10-20m³/d; the relatively constant ratio of power liquid and production Liquid is obtained in the system under different operating conditions, The results show that the whole structure can meet the requirements of large gradient wells or horizontal wells, achieving the production requirements of high gradient and low liquid oil wells.

Keywords: Hydraulic Driving, Screw Pump, reverse circulation, Lift technology.

1. Introduction
With the continuous development of the oilfield, the number of highly deviated wells increases year by year, and some highly deviated wells have the problem of low production. The highly deviated low liquid well in Dagang Oilfield is a kind of onshore highly deviated low liquid well represented by Banqiao, Xiaoji, wangguantun and other deep low permeability reservoirs. It is characterized by deep buried reservoir, low daily liquid production, complex well trajectory, rod pump lifting technology, serious eccentric wear of rod and pipe, short pump inspection period and low pump efficiency. The second is the deep high angle low fluid well in the beach represented by Chenghai area 2. The reservoir is deeply buried with low daily fluid production. Most of them are cluster directional wells and horizontal wells, and the well trajectory is more complex than that on land. Due to insufficient fluid supply, the flow rate of well fluid can not reach the cooling flow rate of motor shell (≥ 0.34m³/s), the problems of unit temperature rising, motor burning and cable breakdown are prominent, and the pump inspection cycle is short.
Table 1. Statistics of onshore high angle low liquid well reservoir and production.

| Oilfield Block | number | Medium depth m | Porosity % | Permeability 10^3μm² | Liquid production m³/d | pump inspection period d | Average maximum deviation angle ° |
|----------------|--------|----------------|------------|-----------------------|------------------------|-------------------------|-------------------------------|
| Banqiao        | 59     | 3120           | 17.1       | 157.5                 | 12.4                   | 235                     | 26.5                          |
| Xiaoji         | 35     | 3285           | 11.8       | 17.5                  | 11.2                   | 270                     | 20.8                          |
| Wangguantun    | 28     | 3014           | 15.1       | 55.5                  | 10.9                   | 255                     | 22.7                          |
| Duanliubo      | 19     | 3319           | 12.6       | 27.6                  | 16.5                   | 208                     | 21.3                          |
| Changlu        | 17     | 3709           | 16.1       | 50.1                  | 5.5                    | 264                     | 27.1                          |
| Zhouqinghun    | 16     | 3100           | 11.1       | 10.1                  | 7.6                    | 227                     | 21.1                          |

In view of the above problems, the hydraulic drive screw pump lifting process test research is carried out. The lifting string adopts the structure design of reverse circulation hydraulic drive screw pump, and the lifting string is equipped with reverse circulation auxiliary setting packer to overcome the problem of insufficient loading of conventional mechanical packer in highly deviated wells, so as to realize the long-term and efficient production of highly deviated and low fluid volume (10-20m³/D) wells and meet the requirements of oil field production Production needs.

2. Technical analysis

2.1. Structure of hydraulic driven screw pump.

The hydraulic driven screw pump lifting system is composed of surface flow system and downhole string. The surface flow system is mainly composed of automatic compensation reservoir, desanding system and degassing buffer equipment. The downhole string is composed of screw motor, transmission assembly, screw pump, packer and anchoring device.

![Figure 1. Hydraulic drive screw pump lifting process structure diagram](image_url)

The surface process adopts the self circulation process structure, a part of the oil well produced liquid enters the reservoir through the desanding system and degassing buffer equipment, and another part is injected into the oil casing annulus as the power through the plunger pump pressurization. The flow structure of self circulation is conducive to the independent operation of the system, without the need for additional power hydraulic water source, and the power hydraulic pressure can be adjusted, which is conducive to parameter optimization.
2.2. Principle of hydraulic driven screw pump lifting downhole string.

The high-pressure power fluid enters from the annular space of the oil sleeve, and then enters the bottom of the screw motor through the radial liquid hole I of the transmission assembly [1]. At this time, the power fluid is squeezed upward from the spiral cavity space of the screw and the bushing in turn. Under the effect of the pressure difference, the screw generates an eccentric force relative to the axis, which makes the screw rod rotate in the spiral channel of the stator bushing, generating a working torque, the rotor of the screw pump is driven to rotate by the transmission assembly. With the rotation of the rotor of the screw pump, the produced liquid moves from the suction end to the discharge end. Then the produced liquid of the oil layer enters the hollow rotor of the screw motor through the radial hole II, and finally the produced liquid of the oil layer and the power liquid mix and return to the ground.

3. Applicable conditions for hydraulic driven screw pump lifting

(1) Suitable well depth: 2000m;
(2) Suitable for deviated horizontal wells;
(3) Oil well liquid production: ≤ 20m³ / D;
(4) It can adapt to gas and heavy oil reservoir;

4. Technical characteristics of hydraulic screw pump

(1) It has the advantages of screw pump (positive displacement pump);
(2) The hollow rotor with equal wall thickness is used to improve heat dissipation efficiency, rubber swelling and thermal expansion uniformity;
(3) It overcomes the serious problem of eccentric wear of rod and tube in highly deviated wells;
(4) It can well adapt to the production of complex oil wells with high sand content, high gas-liquid ratio and heavy oil.

5. Laboratory test of hydraulic driven screw pump lifting

The performance test should run after the normal operation test. The purpose of performance test is to measure the relationship among inlet pressure, inlet flow and outlet flow of hydraulic drive screw lifting system. Through monitoring the operation of the system under different displacement and pressure, recording the data (power fluid displacement, power fluid pressure, outlet displacement), the characteristic curve of the system is obtained, which is the basic basis for adjusting the power fluid
flow and pressure according to the formation liquid supply capacity in the field application. The performance test shall take no less than 6 measured values within the specified flow range of the motor. Each measurement shall be recorded after stable operation, and the operation time of each value is 30 minutes.

![Figure 3. Test schematic diagram](image)

**Table 2. Test data record sheet.**

| Number | Power fluid displacement $Q_{in}$ (L/s) | Power pressure $P$ (MPa) | Export displacement $Q_{out}$ (L/s) | Inhalation volume $Q_s$ (L/s) |
|--------|----------------------------------------|--------------------------|-------------------------------------|-------------------------------|
| 1      | 0.71                                   | 3.85                     | 0.81                                | 0.1                           |
| 2      | 0.79                                   | 3.97                     | 0.9                                 | 0.11                          |
| 3      | 0.85                                   | 4.1                      | 0.97                                | 0.12                          |
| 4      | 0.92                                   | 4.27                     | 1.09                                | 0.17                          |
| 5      | 1.0                                    | 4.46                     | 1.17                                | 0.17                          |
| 6      | 1.12                                   | 4.76                     | 1.3                                 | 0.18                          |
| 7      | 1.2                                    | 5.08                     | 1.4                                 | 0.2                           |

Start the power pump, gradually adjust the power hydraulic pressure, after stable operation, observe the power hydraulic pressure value $P$, fill in Table 2, observe the outlet and inlet flow meters, fill the outlet flow value $Q_{out}$ and inlet flow value $Q_{in}$ in Table 2, and finally fill the suction flow value $Q_s = Q_{out} - Q_{in}$ in Table 2, a group of measured values run for not less than 30 minutes.

According to the data in Table 2, the characteristic curves of inlet pressure $P$-outlet flow value $Q_{out}$, Inlet pressure $P$-suction flow value $Q_{in}$ are obtained (Fig 4), and the characteristic curves of Inlet pressure $P$-suction flow value $Q_s$ are obtained (Fig 5). It can be seen that the suction capacity of the system is 0.1-0.24l/s, which can meet the production needs of 10-20m³/d liquid production. According to the data in Table 2, the characteristic curve of the suction flow value $Q_s / Q_{in}$ is obtained (Fig 5). Through the indoor test, the ratio of suction flow and power liquid is obtained: $Q_{in} / Q_s \approx 5$.

Through the performance test, it can be concluded that the lifting capacity of the hydraulic drive screw lifting system in the best working condition range meets the expectation production needs(10-20m³ /d); through the test, it can be seen that the system has a relatively stable dynamic liquid ratio, which can be used as the basis for adjusting the power pump displacement according to the oil well production capacity.
Figure 4. Relationship between dynamic hydraulic pressure and system suction

Figure 5. Relationship between system suction and power fluid displacement

6. Conclusions
The hydraulic driven screw pump lifting process test research was carried out. The lifting string adopts the hydraulic reverse circulation drive hollow screw structure design, which effectively improves the lifting efficiency. Through the underground lifting string part test, the adjustable range of system suction is 0.1-0.24l/s, It can meet the production needs of 10-20m³/d liquid production; the relatively constant ratio of power fluid and liquid production under different operation conditions of the system is obtained, which provides the basis for on-site adjustment of liquid production; it is verified that the structure can adapt to the lifting requirements of highly deviated wells or horizontal wells, and ensure the production needs of highly deviated and low liquid production wells.

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