Multi-round CO_2 Viscosity-reducing Oil Production Technology without Pulling out Downhole Pipe Column

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Abstract: Carbon dioxide injection can improve the recovery rate of heavy oil and reduce the viscosity of heavy oil as well as reduce carbon emissions. However the downhole tubular material is very easy to react electrochemically with CO_2 under high temperature and humid environment after CO_2 injection, which causes strong corrosion to the downhole tubulars. For directional wells, it will further aggravate the tubular bias wear and cause a significant shortening of the pumping inspection cycle. Moreover production will decrease after a period of time CO_2 throughput and re-injection of CO_2 will be required. In this paper, we have developed a multi-round carbon injection and heavy oil production technology without moving the tubing column. Also the supporting tools match the technology is optimized and improved to achieve the goal of extending the operation cycle and saving cost.

Keywords: Carbon Dioxide Injection, Heavy Oil Production, Hydraulic Jet Pump

1. Introduction

Carbon dioxide throughput is one of the important recovery enhancement technologies, which has the advantages of good effect, quick effect, economic and environmental protection, and wide applicability. It is widely used in many types of reservoirs such as low permeability and tight, fractured, carbonate rock, shale, complex fracture block, etc., and also has a large number of applications in heavy oil reservoirs[1]. During the process of CO_2 drive in heavy oil reservoir, it not only can replenish the formation energy, but also can reduce the viscosity of crude oil, eliminate the interfacial tension and cause the expansion of crude oil after mixing with crude oil. The recovery of crude oil is improved finally. After carbon dioxide injection, the tubular material is very easy to react with carbon dioxide electrochemically, which is very corrosive to the downhole tubulars , and it will further aggravate the rod and tube bias wear for directional wells. A significant shortening of the pumping inspection cycle will be resulted. Moreover, production decreases after a period of production, and CO_2 needs to be injected again to improve the recovery rate. In this paper, we have developed a technology of multi-round carbon dioxide injection and oil production without moving the downhole tubing column to address the shortcomings of production in viscous oil wells, such as the short pumping period and the need to raise the downhole tubing column when injecting carbon dioxide.

2. Researching of Small Diameter Production Pump

The jet pump can have good adaptability in inclined and horizontal wells due to its no moving parts and simple structure, and can effectively avoid problems such as rod and tube deflection grinding. According to the process requirements, smaller size tools are designed (Figure 1, Table 1). The small diameter jet pump adopts two-way micro seal structure (as in Figure 2). The advantage of this seal structure is high pressure-bearing, the higher the pressure the better the seal effect, and occupies less space. The seal material is made of fluoro-elastomer which is more resistant to CO_2 corrosion[2-3]. The nozzle structure was redesigned (Figure 3) to meet the nozzle diameter requirements while solving the problem of internal installation space limitations.

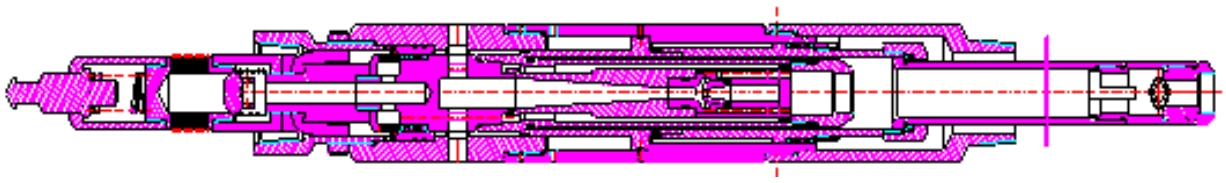


Figure 1. Small diameter jet pump assembly diagram

3. Pipe and Column Design

Lower the $3^1/_2$″ oil pipe as outer pipe column (Figure 4), then lower the 2″ inner pipe column into $3^1/_2$″ oil pipe, and make the insertion of the packer seating seal. Open the slide sleeve by the pressure from space between 2″ and $3^1/_2$″oil pipe, and then drop the pump core from 2″ oil pipe to put the liquid into production and discharge. The return liquid is discharged to the surface from the annulus of 2″ and $3^1/_2$″ oil pipe, while the gas is discharged to the surface process from the annulus of $3^1/_2$″ oil pipe and casing. Even if the pump is stopped, the fluid in the tubing will not flow to the bottom of the well and cause back pressure. When you need to inject carbon dioxide again, you can inject carbon dioxide from the oil casing annulus without lifting out the tubing column, and put the pump core into production after the well is bored.

Table 1. Tool Characteristics Parameters

Working cylinder diameter	Outer diameter of working cylinder	Pump core outside diameter	Casing size	Temperature	Pressure
Φ30mm	Φ70mm	Φ36 mm	≥ 51/2″	≤120℃	≤70MPa



Figure 2. Small diameter pump core seal structure diagram

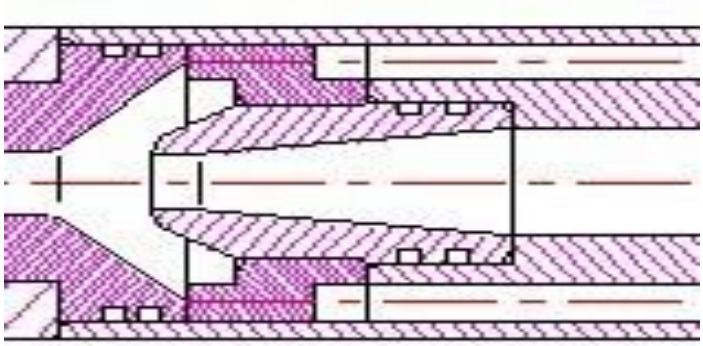


Figure 3. Small diameter nozzle structure diagram

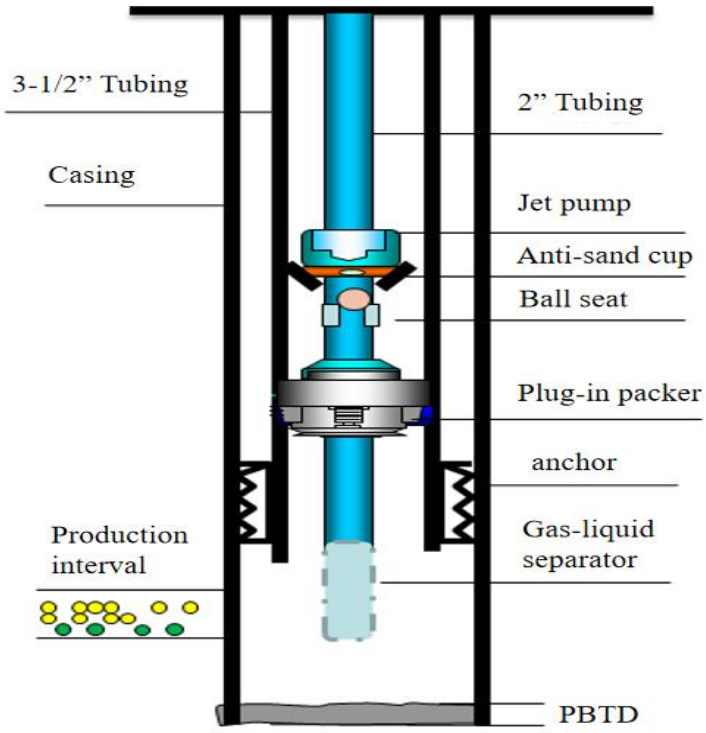


Figure 4. Schematic diagram of tube and column structure

4. Technology Features

The downhole pipe column will not stretch back and forth when discharging liquid, but under high pressure and high temperature, the oil pipe will elongate.There is a possibility that the 3″oil pipe and 2″oil pipe will stretch inconsistently in the process of stopping and starting the pump, which cause the insertion seal to move back and forth and damage the seal. For this reason, the anti-sand tubing anchor is installed on pipe column to fix the outer oil pipe and to avoid back and forth movement, but also to ensure that the pipe column in the middle of the casing, reduce the bending, conducive to the pump core into and wash out[4-5].

The annular space between the two layers of oil tubes is finite. In order to avoid sand jam, a green pipe is installed at the bottom end of the 3″oil tube to avoid the entry of large sand particles. In order to avoid sand jam, an anti-sand cup is installed at the upper end of the inner tube to ensure smooth uncoupling once the sand is stuck.

In the inner tubing string, the distance between the hydraulic jet pump cylinder and the anti-sand cup is as short as better. With which, the sand can be discharged in a timely manner and the operation is conducive to pulling out the string even if the sand settles due to pump stoppage and other reasons.

5. On-site Applications

The K10-9 well was completed on 2014.01.20 with a completion depth of 1421.0m and a maximum well deviation of 24.66°, using 5-$^1/_2$" N80 production casing. The well was stopped production without fluid at the wellhead on 2016.03.22and shut in as planned on 2016.12.07 The crude oil analysis report shows that the crude oil density: 0.9754g/cm^3 (20°C), 0.9592g/cm^3 (50°C); viscosity: 3073.12 mPa.S (50°C).CO_2 throughput was implemented in 2020, respectively on 2020.03.04-07 CO_2 throughput with a total of 247.85 m^3 of CO_2 injected, 2020.10 In 2020, the CO_2 throughput was carried out on 2020.03.04-07, with a total of 247.85 m^3 of CO2 injected, and on 2020.10.07-12, with a total of 310 m^3 of CO_2 injected, and on 2020.11.24, 2021.04.30, and 2021.07.28, with a short pump inspection period. After switching to concentric double-pipe small-diameter jet pump column production, the pump check cycle was significantly extended and production was stable.

6. Conclusion

- The downhole pipe column can achieve multi-round CO_2 throughput for heavy oil production without moving the downhole string, and is suitable for complex wellbore structures such as inclined wells and directional wells.
- Small-diameter injection pumps optimized for the characteristics of the downhole column can meet the requirements of gas sealing. The carbon dioxide corrosion-resistant tubes and seals are used to tools to extending the life of the pump.

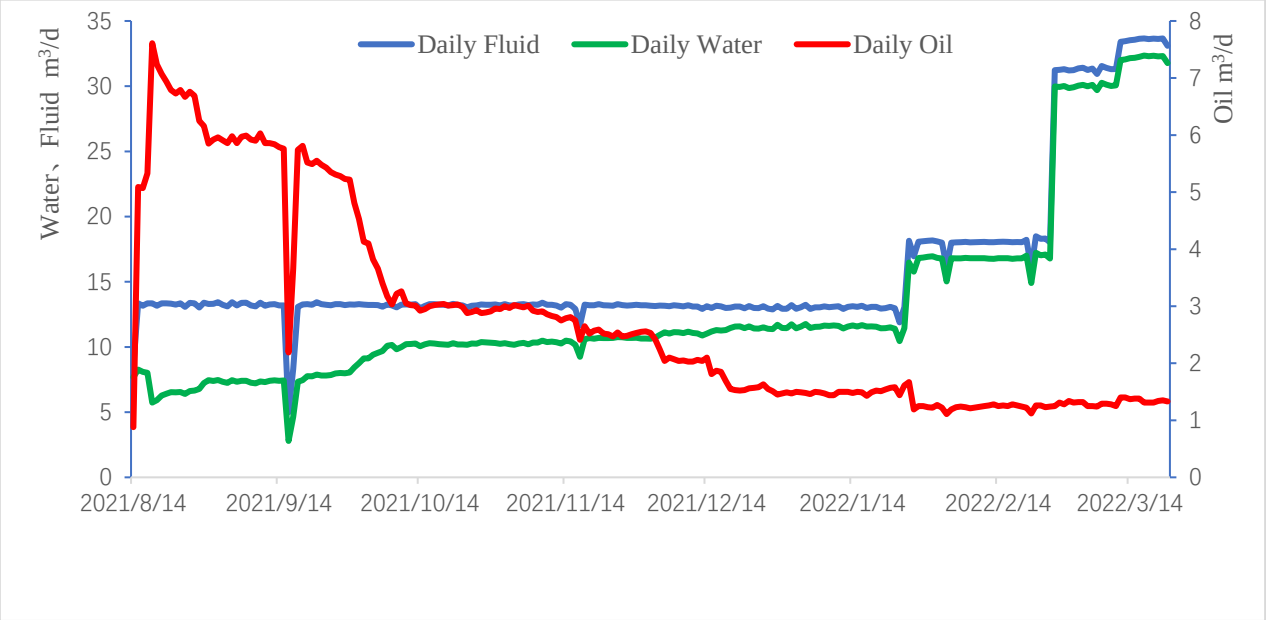


Figure 5. K10-9 production data

- Field application results show that this technology can effectively extend the pump inspection cycle and reduce the frequency of well repair operations.
- The efficiency of small diameter jet pump due to the size of the significant reduction in pump is affected to a certain extent. the pump core structure in subsequent researches needed to optimize further to improve pump efficiency.

References

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