Research of efficient development of new technology in the deep water marginal oil and gas reservoirs

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Abstract

The oil and gas resources of offshore oilfield are rich in our country. As the scale of oil and gas production inland is getting smaller, the government has transferred the core of oil and gas resources exploitation to the deep water oil and gas fields. As the development cost of the offshore oil and gas field is quite high, and the durable years of the equipment is too short, the development of the offshore oil and gas field has been limited to the large-scale reservoirs, which has ignored the effective exploitation of small marginal oil and gas reservoirs. It has caused the waste of resources. To get this problem solved, a new technique: oil and gas wellbore transmit technology, which is developed for the effective exploitation of the small marginal oil and gas reservoirs is raised. It can collect the oil and gas fluid from small marginal oil and gas reservoirs to the large oil and gas reservoirs through the establishment of artificial transmission shaft. Then use the existing facilities of the large reservoir to realize the indirect development of the marginal oil and gas reservoirs. This technique can realize the combination of small marginal reservoirs and large reservoirs in development mode and it's a new technique for the deep small reservoir which is economic, environmental and efficient.

Keywords

Offshore oil and gas fields; the marginal oil and gas reservoirs; oil and gas wellbore transmit technology; manual transmission shaft.

1. Introduction

The oil and gas resources of offshore oilfield are rich in our country. Until now, the oil and gas production inland has presented a decreasing tendency, but the country's oil demand is growing steadily, the sustained growth of oil production in offshore reservoir has become an important component in the national oil production growth and replacement[1]. Various types of reserves which have been found in China are 61×10^8t,they are mainly in Bohai sea area. Their oil reserves have already accounted for more than two-thirds of the Bohai sea total reserves, heavy oil production will account for more than 60% of China's offshore oil production till 2010[2]. Until now the development of offshore oil field has focused on large offshore reservoirs whose abundance is better. While limited to the cost of development and development scale the small marginal reservoirs around the large reservoirs has not been exploited effectively. It has caused the waste of resources. Whether the marginal reservoirs can be developed effectively is closely related to the current development mode, exploitation technology and the economic environment. It is timing and staging[3-5].

If uses the traditional development mode to get the small marginal reservoirs exploited, there are a few problems need to be solved:

(1)The scale of oil and gas reserves is small, the scale of reserves and production capacity is difficult to meet the needs of maritime efficient development[6].

(2)The cost of offshore drilling platforms and facilities is quite high, if sets a new development system for the small marginal reservoirs, the total development cost is too high.

(3)The production and maintenance costs are too high, and the life of a facility is too short.

Therefore, as for the small offshore marginal reservoirs, a new development mode should be explored to realize the full use of the small reservoirs under the premise of not increase the cost of development too much.

2. Oil and gas wellbore transmission technology

The basic idea for "oil and gas wellbore transmit technology"is: to establish the oil and gas transmission channel underwater by placing the artificial transmission shaft underwater and transfer the oil and gas fluid from the small marginal reservoir to the large reservoir whose physical property is better. Finally, the development of the small reservoir can be realized by using the established offshore platform and well pattern operating system from the large reservoir. This method can make full use of the established operating system to carry out the exploitation. This method can reduce the difficulty and the operating cost in developing the small reservoir separately. And it is a new oil and gas mining technology which is effective and economic.

The basic principle of "Oil and gas wellbore transmit technology" is: since the development life of the large reservoir is very long, the formation pressure decreased obviously. Therefore, by using the pressure difference between the original formation pressure of the small reservoirs and the current formation pressure of the large reservoir as well as the drainage effect of the transmission shaft underwater, the transmission of reservoir fluid from the small reservoir to the large reservoir can be realized. The well type of the artificial transmission shaft can choose the directional well or horizontal well according to the actual circumstance of reservoir. At the same time, the flow of the artificial transmission well and the operating time can be controlled artificially. The schematic diagram of "Oil and gas wellbore transmit technology" as follows.

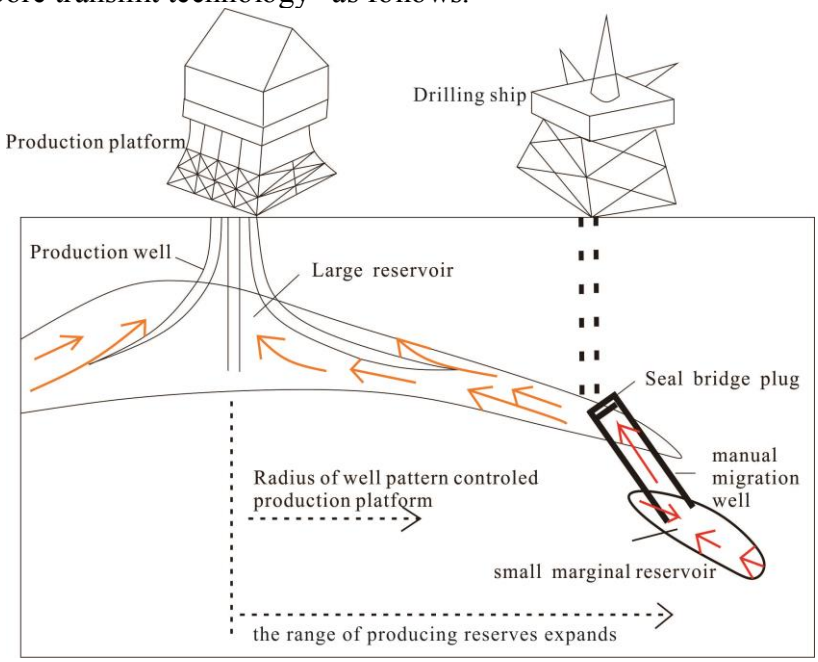

Fig 1 Schematic diagram of wellbore transmit technology

3. Wellbore flow calculation

The whole transmission can be divided into 3 parts: The first part is the seepage of the fluid from small reservoir to the entrance of manual transmission shaft; The second part is the pipe flow in the manual transmission wellbore; The third part is the seepage from the export manual transmission shaft to the large reservoir. To get this process realized, the pressure and flow should be controlled in the whole process. At the same time, the capacity of the flow decides the feasibility of the whole "Oil and gas wellbore transmit technology". Now use the equal permeating resistance method and the calculation method of node system to calculate the flow of the wellbore.

3.1 Equal permeating resistance method

The equal permeating resistance method is to describe the seepage field with the electric field, and then solve the more complicated well-drain seepage in accordance with the principle of similar hydropower[7]. The whole process is the superposition of the three process. The flow resistance of the process is as fig 2 showed.

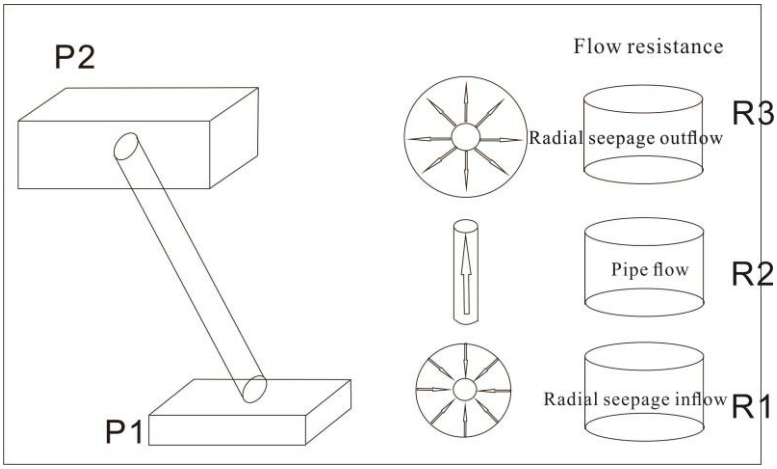

Fig 2 Schematic diagram of flow resistance

The total transmission flow can be described as:

$$Q = \frac{P_1 - P_2}{R_1 + R_2 + R_3} \tag{1}$$

In the formula: Q ——the total flow of the oil and gas that is transmitted;

P_1 ——the original formation pressure of the boundary of the small reservoir;

P_2 ——the formation pressure of the boundary of the large reservoir;

R_1 ——the seepage resistance from the supply edge small reservoir to the entrance of the transmission shaft;

R_2 ——the flow resistance inside the shaft;

R_3 ——the seepage resistance from the export of the transmission shaft to the supply boundary of the large reservoir.

Firstly, improve the transmission flow by improving the pressure difference between the small reservoir and the large reservoir. Therefore, when choosing the target reservoir, optimize the reservoir which has the bigger pressure difference to transmit the oil and gas. In this way, the transmission efficiency will be improved.

Secondly, improve the whole transmission flow by reducing the resistance in the process of oil and gas transmission. The specific operation includes:

(1)Optimize the places where the physical property of the reservoir is better to place the manual transmission well.

(2)The reservoir protection of the inflow and outflow wellbore should be prepared to reduce the pollution of the reservoir[8].

(3)Place the outflow wellbore of the manual transmission shaft near the existing production wells of the large reservoir and reduce the distance from the export of the transmission well to the production well of the large reservoir. And reduce the flow loss in this flowing process. As for the transmission of the natural gas, as its viscosity is small, its transmission speed is higher than the oil. At the same time, the lower the viscosity of the oil is, the higher the transmission efficiency is.

3.2 The calculation method of node system

The basic idea of the calculation method of node system is to set the node in a link to isolate the system into relatively independent subsystem. Connect the mathematical model of the flow pressure and the relationship which is isolated by the node to determine the flow of system[9]. The whole process of oil and gas transmission can be divided into four nodes:(1)the boundary of the small reservoir;(2)the entrance of manual transmission shaft;(3)the export of manual transmission shaft;(4)the boundary of the large reservoir. Node dividing diagram is shown in figure 3. The transmission process from node 1 to node 2 and mode 3 to node 4 conform to the flowing patterns and seepage laws of the oil, gas and water in the porous medium of the formation. Therefore, the flow can be calculated by using the seepage equation in poromechanics. The transmission from node 2 to node 3 can be calculated according to the pipe flowing rule of the conventional fluid. The node analysis equations can be established by using the reservoir seepage equation, pipe flow equation inside the shaft, initial value of the boundary and the same value of the pressure and flow rate of the same node to get it solved cooperatively and obtain the pressure and flow rate of each node[10]. Nodes are as shown in figure 3.

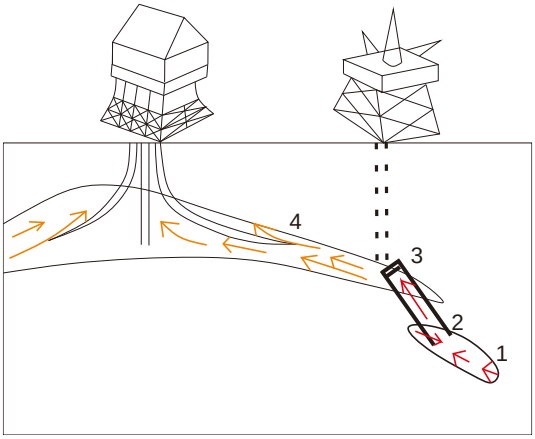

Fig 3 Node classification diagram

In the process of actual calculation, the productivity equation of dynamic process of the first rank is established according to the pressure and physical property of the small reservoir. The deliverability curve of the process from node 1 to node 2 can be made according to the deliverability equation. The deliverability equation of the third process can be made according to the pressure and physical property in the same way. The deliverability curve of the process from node 3 to node 4 can be made according to the deliverability equation. In the process of actual calculation, the resistance and flow loss which is made inside the shaft can be ignored so that it can be approximately considered that the fluid maintains the same pressure inside the shaft. The transmission flow inside the manual transmission shaft will be obtained when the two deliverability equations are calculated. The two deliverability curves are as shown in fig 4.

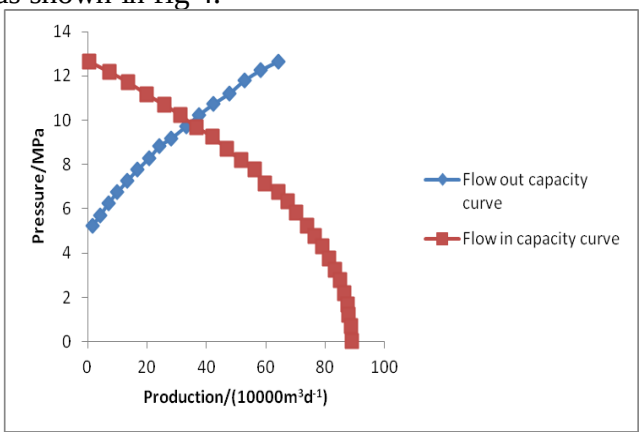

Fig 4 Deliverability curves

4. Technical application field

"Oil and gas wellbore transmit technology" is mainly used in the following reservoirs:

(1)The marginal reservoir which is small and far away from the large reservoir. As this kind of reservoir is small, if it is developed by the regular pattern, the cost will be high, and the obtained economic benefit is low. The feasibility of the development will be poor. The oil and gas wellbore transmit technology can connect the small reservoir to the large reservoir. Therefore, the small reservoir can be exploited by the existing platforms of the large reservoir. This technique has not only fully got used of the small reservoir, but also expanded the controlled range of the existing well pattern in the large reservoir. It has realized the high efficiency exploitation.

(2)The gas reservoir which has got bigger original formation pressure. In the south China sea, the pressure coefficient of some high pressure gas reservoirs can be more than 2.0. It can not be developed safely and efficiently with the existing production mode. It should be controlled by the anticorrosive material which is resistance to high pressure so that the cost for each well will be added. While the "oil and gas wellbore transmit technology" can effectively use the formation pressure of the gas reservoir which has got high pressure to transmit the natural gas to the gas reservoir which has got low pressure. It has effectively reduced the cost of the high pressure reservoir in the process of exploitation and improved the safety of operation at the same time.

(3)The gas reservoir which has got high amount of CO_2. The The traditional development mode of this reservoir needs to improve the cost in corrosion protection of the shaft and platform facilities. At the same time, in the final output natural gas, the content of CO_2 is too high, it needs some degassing costs and has also polluted the environment. The "oil and gas wellbore transmit technology" can transmit the natural gas which has got high amount of CO_2 to the high hydrocarbon gas accumulation. The CO_2 can drive the high hydrocarbon gas to the production well to get it exploited. Therefore, this kind of technology can not only improve the gas reservoir recovery efficiency but also ensure the protection of the environment.

5. Conclusion

(1)The manual transmission well underwater can realize the collection of the oil and gas fluid from the small marginal reservoir to the large reservoir. The effective development can be realized by using the existing production platform and exploitation system of the large reservoir. The effective development can be realized by using the existing production platform and exploitation system of the large reservoir.

(2)As for the gas reservoir which has got abnormal high pressure, this technique can make full use of its character of high pressure to drainage the high pressure gas to the low pressure gas reservoir in order to transfer it into the low pressure gas reservoir. In this way, it will be transferred into the exploration of the conventional low pressure gas reservoir which has not only reduced the operation difficulty but also ensured the safety.

(3)As for the gas reservoir which has got high amount of CO_2, the cost of the platform facilities in the conventional development mode is too high. Large amount of CO_2 discharged and it has not only reduced the production efficiency but also polluted the air. The "oil and gas wellbore transmit technology" can use the CO_2 to realize the process of gas driving. It has improved the ultimate recovery of gas reservoir.

(4)The technology has reduced the cost of drilling, completion, engineering and platform maintenance. As the technique uses the existing production facilities of the large reservoir to realize the exploitation of the marginal reservoir, it has reduced the cost in setting up these facilities again.

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