Application of 3D Geological Modeling and Numerical Simulation Technology of Computer in Modern Reservoir Development

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Abstract. With the unrestricted exploitation of oil reservoirs in China, the problems of rising water content and decreasing oil production of oil wells continue to appear. What's more, the over exploitation of reservoir will lead to the decrease of formation pressure. The decrease of underground pressure will lead to the expansion of rock skeleton. This phenomenon will lead to expansion engineering accidents. The numerical simulation of oil reservoir based on computer geological modeling, as a cutting-edge technology which can combine geological model and oil production performance, has achieved good results in oil production. More and more attention has been paid to numerical simulation technology in oilfield exploitation.

Keywords: Geological Modeling, Numerical Simulation, Reservoir Development

1. Introduction

It has been proved by practice that in the later stage of low permeability oilfield development, due to the frequent increase of production measures, the mixing relationship between underground oil and water is very complex[1]. This situation leads to the unsatisfactory development effect of the oilfield. At present, how to make full use of the existing scientific and technological means to analyze the formation cause and distribution characteristics of underground oil and improve the effect of reservoir development is a topic of concern for oilfield development workers. At present, the main research methods are dynamic method, core lifting method and numerical simulation method.

As we all know, most of the oil fields in the world are low permeability reservoirs. The distribution of underground oil and groundwater is very complex. Without good analysis equipment, people can’t determine the specific oil recovery plan[2]. Compared with dynamic method and core lifting method, numerical simulation method has special advantages. It can help people directly see the distribution of
oil and groundwater through a large number of complex calculations.

2. Geological survey

In the application of computer modeling system in reservoir exploitation, the key point of numerical simulation and dynamic prediction is to establish reservoir geological model. In short, the oil tank model is designed to make the actual reservoir numerical and comparative analysis of various data about the oilfield. The computer can describe the dynamic reservoir characteristics of the oilfield in detail through the simulation software.

2.1. Setting of simulated area range

The numerical simulation area is located in an oil field of You Fang Zhuang. 31 wells are set as 1 reservoir. The area of the simulation area is set at $4.65 \text{km} \times 7.5 \text{km}$. The total number of oil and water wells is 92.

2.2. Division of computer simulation layer and construction of plane network

The selection of grid should be isometric grid of Cartesian coordinate system. The construction of plane grid should ensure that there are three empty grids between two wells. The spacing between flat grids cannot exceed 50m. In the longitudinal direction of the grid, each simulation layer should be separated by 3m. The grid shall be in steps of 50m. The reservoir group should be divided into four sand groups. The 4 sand formations should be divided into 24 simulated layers. The 24 simulation layers should be divided into 9 flow units\(^4\). The total number of grids is 234360.

3. Establishment of geological model of oil field

3.1. Requirements for model construction

The establishment of three-dimensional geological model is the discrete analysis of geology. It is mainly used to represent the characteristics of surface structure and stratification of oil field. The depth and thickness data of each grid are very important in the model construction\(^5\). In addition, we should pay attention to the relationship between the geometric shape of the top structure and the space of each mesh.

3.2. The establishment of sand skeleton model

The geometric model of sand body represents the geological reservoir structure in the form of data. It is also known as the continuity and configuration relationship of sand bodies. The framework of sand body is mainly composed of sand layer thickness and net sandstone thickness. The sand layer thickness is usually the simulated layer thickness\(^6\). The net sandstone thickness represents the size of the permeable layer of each grid.

3.3. The construction of physicochemical model

The immaterial physicochemical model reflects the spatial characteristics of porosity and permeability in the reservoir in the form of parameters. Porosity and permeability represent the storage capacity and permeability of the reservoir. Therefore, in various models, the establishment of physical and chemical
model is the key link of building geological model.

3.4. Establishment of oil field distribution model

The distribution model can express the spatial distribution of oil, gas and water in oil field with data. Each grid can reflect the oil, gas and water saturation of each part.

4. Dynamic fitting and result analysis

4.1. Initial operation of reservoir model and setting of liquid parameters

The initialization of the model refers to the data of formation pressure and saturation pressure given to each grid by computer. The computer simulation system uses the balance condition of gravity and pressure to automatically initialize the reservoir model according to the parameter value input by the user (see Table 1). All parameters of the liquid and rock used in the simulation calculation are the data of laboratory experiment analysis.
Table 1. Investigation on the difference between the historical information of water content and the calculation results of logging

| Time | Calculation results | Actual results |
|------|---------------------|----------------|
| 1986 | 21%                 | 19%            |
| 1987 | 21%                 | 22%            |
| 1988 | 40%                 | 38%            |
| 1989 | 33%                 | 33.5%          |
| 1990 | 32.5%               | 33.4%          |
| 1991 | 43.1%               | 42.5%          |
| 1992 | 43.5%               | 40%            |
| 1993 | 38%                 | 42%            |
| 1994 | 50%                 | 48%            |
| 1995 | 50.2%               | 49.5%          |

4.2. Dynamic fit

Dynamic fitting includes reserves fitting, oil production fitting, water cut fitting and pressure fitting. The fitting parameters of reserves need the thickness and porosity of the reservoir. The matching of oil production needs to consider various measures in development and production and the factors of fracturing and acidizing measures. The fitting result of water content is almost the same as the calculation result of actual water content (see Table 2). The fitting of pressure is the fitting of underground permeability and compression parameters based on the fitting of geological reserves.

Table 2. Investigation on the difference between the historical information of well logging pressure and the calculation results

| Time | Calculation results | Actual results |
|------|---------------------|----------------|
| 1986 | 13Mpa               | 13Mpa          |
| 1987 | 12.6Mpa             | 12.5Mpa        |
| 1988 | 12.4Mpa             | 12.5Mpa        |
| 1989 | 12.5Mpa             | 12.5Mpa        |
| 1990 | 11Mpa               | 10.3Mpa        |
| 1991 | 10.5Mpa             | 10.5Mpa        |
1992  10.5Mpa  10Mpa
1993  8Mpa  7Mpa
1994  7.5Mpa  7Mpa
1995  6.9Mpa  7Mpa

4.3. Distribution rule of saturation of remaining crude oil

After the completion of the dynamic simulation, we can find that the saturation of the remaining oil is mainly distributed in the higher geological position. Generally speaking, the second sand formation should be the most developed. The recovery degree of small layer geology is between 4.58% and 32.29%. The recovery degree of sand formation is 16.87%. Compared with the second layer group, the third layer group has a medium degree of utilization. The fourth layer has the lowest utilization degree.

5. Optimization method of oilfield development plan

5.1. Rational use of new adjustment well and old sidetracking well

According to the distribution of remaining oil, we can use new adjustment wells to change from low production wells to water injection wells in the marginal areas of the reservoir and the areas where the density of remaining oil is low. For the central area of the reservoir, the abandoned wells or low production wells are generally used to sidetrack the old wells.

5.2. Perfection of well pattern

According to the analysis of the distribution map of the remaining oil saturation, the corresponding layer injection holes are taken and the injection production well pattern is improved at the well points with and without oil injection wells.

5.3. Tapping the potential of remaining oil

Using the engineering method of oil recovery to tap the potential of remaining oil is a common economic method. According to the profile analysis of water injection well, water plugging measures are taken in the main layer of water production well. This way can reduce water cut and improve the effect of water injection.

6. Conclusion

According to the research of numerical simulation technology, we can find that the remaining oil is mainly distributed in the position of high structure and the main channel of deposition. According to the distribution characteristics of the remaining oil, we can predict the adjusted development index after the optimization of three methods. We can find that the numerical simulation and the optimization of the development plan are effective.

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The papers’ project: Study on the fracture characteristics of narrow thin sand body oilfield and the method of dredging residual oil in fault area.

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