Status analysis and development of reservoir numerical simulation technology

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Abstract. In recent years, with the continuous development of computer, applied mathematics and reservoir engineering, reservoir numerical simulation method has been improved and widely used. Through numerical simulation, we can make clear the fluid flow law, oil displacement mechanism and spatial distribution of remaining oil in the reservoir; study reasonable development scheme, select the best production parameters, and obtain the highest recovery factor and maximum economic benefit with the least investment and the most scientific production method. In order to meet the needs of the development of petroleum industry, reservoir numerical simulation technology has made great progress in recent years. The appearance of the development direction of fine reservoir numerical simulation is the most intuitive display of this progress. Therefore, this paper carries out a specific study on the research status and development trend of fine reservoir numerical simulation, hoping that this research can make more people understand the multi-disciplinary and one-dimensional The development trend of fine reservoir numerical simulation, which includes physical, high-speed, multi-functional integration and system coupling simulation.

Key words: reservoir numerical simulation; geological model; refinement.

With the rapid development of petroleum industry, the general reservoir simulation technology has been unable to meet the needs of oilfield development, and the concept of fine reservoir numerical simulation has been proposed. As early as the 1980s, a large number of researches on fine reservoir numerical simulation have been carried out in the world. However, there is no strict standard division of "fine" in this period, which makes it difficult to grasp the fine degree of fine reservoir numerical simulation for a long time. In this paper, the research on the research status and development trend of fine reservoir numerical simulation will mainly focus on the description of reservoir geological model, fluid movement description and the precision of simulation model solution.

1. Application of fine reservoir description methods and achievements

In the first mock exam of the development of fine reservoir simulation, the accuracy of the geological model directly relates to whether the simulation can be expanded in a high quality. This makes the fine reservoir description method and results better applied in the fine reservoir numerical simulation, which is mainly due to the precise geological model provided by the application, and the final result of the fine
reservoir numerical simulation is reliable. It can also achieve better improvement. In recent years, domestic scholars have carried out a lot of attempts on the application of fine reservoir description methods and achievements. High resolution sequence stratigraphy, reservoir stochastic simulation, flow unit constraints and so on are all fine geological methods and related achievements adopted in this study.

1.1. Fine reservoir numerical simulation with flow unit constraints
In the fine reservoir numerical simulation under the fine geological method of flow unit constraint, the application of this fine geological method mainly uses the different physical properties and flow characteristics of different flow units, and thus the accuracy of fine reservoir numerical simulation can be improved by selecting the corresponding relative permeability curve. It is worth noting that in the application of this fine geological method with constraint of flow unit, whether there is subdivision flow unit vertically must be considered. Generally speaking, when there is no interlayer in the layer and the thickness of single layer is less than 5m, it is unnecessary to subdivide, so as to avoid the problem that the fine research of remaining oil cannot be carried out. In recent years, in a large number of research and practical applications, the fine reservoir numerical simulation with flow unit constraints has been gradually recognized by the industry for its high degree of initial fitting and accurate reflection of remaining oil distribution. This also shows that the application of this fine reservoir description method and results can really improve the precision of fine reservoir numerical simulation.

1.2. Fine reservoir numerical simulation for high resolution sequence stratigraphy
For the fine geological method of high-resolution sequence stratigraphy, the application of this method in fine reservoir numerical simulation can realize the stratification and heterogeneous zoning of reservoir physical model. Because this kind of stratification and zoning combined with the results of high-resolution sequence stratigraphy, it makes the physical model of reservoir more in line with the actual situation, fine reservoir numerical simulation Naturally, it will get more powerful support. However, it is worth noting that compared with the fine reservoir numerical simulation applied by fine geological methods such as flow unit constraint, the accuracy improvement of fine reservoir numerical simulation brought by high-resolution sequence stratigraphy is relatively limited.

1.3. Fine reservoir numerical simulation of reservoir stochastic simulation method
In addition to the above two fine geological methods, reservoir stochastic simulation can also be applied to fine reservoir numerical simulation, and the realization of this application mainly benefits from the research results of mudstone spatial distribution and reservoir heterogeneity, which provide the support of early means for fine reservoir numerical simulation. Water injection development of heterogeneous reservoirs can also get some inspiration. Due to the tendency of reservoir stochastic simulation method, the fine reservoir numerical simulation under this fine geological method can calculate the water injection well water injection time by controlling the spatial distribution of sedimentary facies. However, because the calculation of water production time itself needs to rely on random simulation, this fine reservoir numerical simulation is not popular. It is worth noting that in the application of reservoir stochastic simulation method in fine reservoir numerical simulation, the increase of available information will enhance the popularity of this fine reservoir numerical simulation to a certain extent, and the true reflection of reservoir distribution in statistical sense will become possible.

2. Application of reservoir and fluid dynamic change model
In addition to the several fine reservoir numerical simulation based on static geological model mentioned above, considering that the reservoir property and fluid are constantly changing in the process of oilfield development, the application of the model reflecting the dynamic change of reservoir and fluid in the fine reservoir numerical simulation has also attracted extensive attention from the academic community. The application of dynamic tracking simulation belongs to the research product of this concern.
2.1. Application of rock mechanics method
For the fine reservoir numerical simulation of the application of rock mechanics method, the rock mechanics method here belongs to the typical research method of reservoir physical property change, and the realization of physical property change, fracturing and sand production simulation can improve the precision of fine reservoir numerical simulation to a certain extent. In the industry, fine reservoir numerical simulation based on rock mechanics method has been widely used.

2.2. Dynamic tracking simulation application
Considering that oilfield development itself belongs to a relatively long-term process, and the physical properties of reservoir and crude oil are constantly changing in this process, the application of dynamic tracking simulation in fine reservoir numerical simulation can achieve good results. Specifically, in the process of dynamic tracking simulation, we can adjust the time of numerical simulation combined with the development period of oilfield and the changes of oil and water well measures, and in the implementation process of the scheme, we can also realize the tracking simulation of the effect and production status under the support of dynamic tracking simulation, which will make the understanding of reservoir structure and production performance more reasonable. It is worth noting that due to many constraints on the analysis of quantitative change of permeability, it is impossible to realize accurate quantitative calculation in fine reservoir numerical simulation under dynamic tracking simulation. However, combined with monitoring data and development data, dynamic tracking simulation can improve the precision of fine reservoir numerical simulation to a certain extent.

2.3. Application of numerical simulation of fluid solid coupling
In addition to the above two aspects, fluid solid coupling numerical simulation also belongs to the application of reservoir and fluid dynamic change model in fine reservoir numerical simulation. This application is mainly due to the strong fluid solid coupling effect in reservoir development. In the conventional fine reservoir numerical simulation, the influence of fluid solid coupling effect on oil and gas seepage is often ignored, which is mainly due to the failure of simultaneous model of rock deformation process and fluid solid coupling, and the prediction of reservoir production performance often leads to large errors, which brings about a relatively negative impact on oilfield development. In order to solve the problem of fine reservoir numerical modeling caused by fluid solid coupling, in recent years, scholars have realized the combination of percolation mechanics and rock mechanics, and the theoretical calculation model based on this has included porosity, pore compressibility, etc., which can ensure that the fluid solid coupling numerical simulation is really applied to the fine reservoir numerical simulation, and the fine reservoir numerical simulation is precise. The degree will also be improved.

3. Application of grid technology and numerical method
For the fine reservoir numerical simulation, the solution of the simulation model is also related to its own accuracy, which makes the academic research on the solution of the fine reservoir numerical simulation always in an endless stream, and grid technology and numerical solution are outstanding in this kind of research.

3.1. Application of Grid Technology
In general fine reservoir numerical simulation, the application of traditional Cartesian grid, grid orientation effect, horizontal well technology and refined geological model will bring certain negative impact on the simulation solution. In order to minimize the impact, PEBI grid, cvfe grid and FAC grid appear one after another, and the emergence of these grids brings about a lot of difficulties for the solution of fine reservoir numerical simulation. For strong support, PEBI grid is a kind of local orthogonal grid, which has strong stability and convergence in fine reservoir numerical simulation due to its simple and consistent characteristics when local grid is encrypted, which makes PEBI grid better serve for fine reservoir numerical simulation of complex geometry reservoir; for cvfe grid, it belongs to non orthogonal Grid can also be called control volume finite element mesh. Cvfe grid adopts the method
of determining upstream according to flow sign, which makes cvfe grid meet more extensive needs of fine reservoir numerical simulation compared with PEBI grid; and for fac grid, it can also be called adaptive combined grid method, and the formation of fac grid adds local addition Dense grid, which makes fac grid can realize dynamic local grid encryption and parallel operation, and the solution of fine reservoir numerical simulation can also get more powerful support.

3.2. application of numerical method
In addition to the application of grid technology, the application of numerical solution can also better meet the needs of fine reservoir numerical simulation. Matrix discretization method, boundary treatment, optimization of algebraic equations numerical solution are all typical applications of numerical solution in fine reservoir numerical simulation. For the matrix discretization method, the difference method is the main component. Because the difference method itself belongs to the fully implicit and adaptive implicit method, it has the advantages of simple operation process and no need to estimate the eigenvalue of matrix, which can better serve the numerical simulation of fine reservoir.

4. Development trend of fine reservoir numerical simulation
Combined with the above content, we can intuitively understand the research status of fine reservoir numerical simulation, and in order to complete the research in this paper, we also need to clarify the development trend of fine reservoir numerical simulation. Combined with relevant literature and actual cognition, this development trend is summarized as the development towards integration, the continuous improvement of simulation speed, and the simulator the multi-functional integration and solving algorithm are developing to the direction of discretization. To be specific, it refers to the fully implicit fine reservoir numerical simulation realized by the whole reservoir system in the direction of integration; while the simulation speed continues to increase, the development trend is mainly due to the rapid development of computer information field, and new numerical format and phase balance algorithm also play an important role in it; and for the development trend of multi-function integration of simulator, the development trend is that the development of multi-functional integration of the simulator This is closely related to the increasing functions of simulators, which is easy to maintain and redevelop. For the development of solving algorithm to discrete method, the author's discussion in the application of numerical solution can better convey this development trend.

5. Conclusion
In this paper, the research status and development trend of fine reservoir numerical simulation are discussed in detail, including the application of fine reservoir description method and results, the application of reservoir and fluid dynamic change model, the application of grid technology and numerical solution The development trend of fine reservoir numerical simulation, such as multi-functional integration and integration development, can be more in-depth understanding of fine reservoir numerical simulation, hoping that this cognition can bring some inspiration for the better development of China's oil industry.

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