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NEW DEMANDS FOR APPLICATION OF NUMERICAL SIMULATION TO IMPROVE RESERVOIR STUDIES IN CHINA

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Abstract. After years of production, most oilfields with nonmarine deposits in China have been at their mature stage with high water cut and high recovery. The remaining oil is, on one hand, highly scattered in the reservoir, but on the other hand, relatively concentrated in some locations. The identification of the exact distribution of these locations with relatively abundant remaining oil is of great importance for improving oil recovery, but is very difficult. The oilfield development, which has been complicated by all the above factors, calls for more powerful numerical reservoir simulation techniques. The large-scale sophisticated numerical simulation technique with high efficiency, high precision, and high computing speed will be the key to the study on the remaining oil distribution for oilfields at their mature stage with high water cut. As for various types of complicated reservoirs, it is essential to develop different fluid flowing models and corresponding numerical simulation techniques.

Key Words. Oil reservoir, numerical simulation, high water cut, remaining oil distribution.

1. First section:Introduction

This is the first section. Statistics show that more than 90In addition, tertiary recovery techniques such as polymer flooding, alkaline/surfactant/ polymer combination flooding can be used in a lot of oilfields in China to enhance oil recovery. Moreover, a lot of fractured sandstone reservoirs with low and extra-low permeability have been found, the development of which is more complicated. Therefore, numerical simulation demands for improved functions in such cases.

2. Second section:Large-scale sophisticated numerical simulation technique

This is the second section.

2.1. Combining coarse-gridblock simulation with fine-gridblock simulation. This is the first subsection of the second section. In China, most reservoirs are very heterogeneous both horizontally and vertically. Reservoirs with nonmarine deposits usually have a large number of layers, even above one hundred, showing considerable differences in their properties. In addition, properties also change dramatically within the same layer. Therefore, it is of great importance to make clear the remaining oil distribution in reservoirs, especially those locations with relatively abundant remaining oil. In order to improve oil recovery of reservoirs of various types economically and effectively, it is crucial to drill highly efficient infilling wells

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at locations with relatively abundant remaining oil or to work out other practicable reservoir revitalization measures. In order to picture the horizontal heterogeneity and the large number of layers in the vertical direction, a tremendous number of grid nodes are needed, even reaching or exceeding one million. During the in-depth reservoir study, what we are interested in are the locations with relatively abundant remaining oil. Therefore, we should carry out simulation study with fine grid system only at those locations but not in the whole reservoir. Hence, the optimum practice is to start with a relatively coarse grid system to simulate the whole reservoir to find locations with relatively abundant remaining oil, and then turn to a more refined grid system for simulation at such locations. This strategy can reduce grid number and enhance simulation speed without compromising the precision of remaining oil distribution prediction.

2.2. Parallel computing technique. This is the second subsection of the second section. During the study on remaining oil distribution in mature oilfields, although the strategy of combining coarse-grid system with fine-grid one can reduce grid number and enhance simulation speed, the simulation, especially the history matching, will still consume a great deal of time due to a large number of wells, a lot of workovers, and a long production history. Thus, the simulation speed needs to be accelerated further in the case of large-scale sophisticated simulation. The core of numerical reservoir simulation is to solve a large-scale sparse system of linear equations, which is derived from a large-scale system of partial differential equations. Due to the large amount of time and costs that a large-scale sophisticated simulation needs, parallel computers are highly recommended. The emergence of high-performance parallel computers opens a new stage to numerical reservoir simulation techniques. The parallel computation technique for numerical reservoir simulation has become a hot research interest. In recent years many oil companies, service companies and research institutes at home and abroad employ parallel processing technique to lower production costs and enhance work efficiency. Several service companies have also launched numerical reservoir simulators of parallel computation version. China has carried out several key research projects concerning parallel computation since 1990. Research Institute of Petroleum Exploration and Development of PetroChina, China Academy of Sciences, Tsinghua University and others have all been involved in the study on the parallel computation for numerical reservoir simulation. The study on parallel computation for numerical reservoir simulation has laid a solid foundation for the study on large-scale sophisticated numerical reservoir simulation.

2.3. Streamline simulation technique. This is the third subsection of the second section. Although parallel computing technique has been well developed, it is still essential to develop streamline simulation technique with a higher speed when using simulators to predict the remaining oil distribution in mature oilfields. In a streamline simulation, the pressure equation is solved on an underlying grid system using the same method as in a conventional simulation. Next, a nature transport network is constructed based on the orthogonality between streamlines and pressure contours [2] and fluid is transported along streamlines to track oil/water/gas movement within the reservoir. The streamline method therefore has an inherent advantage because the fluid is transported just one dimensionally along streamlines and not between 3-D grid blocks. Because of this simplicity and greater stability, larger time steps with less sensitivity to grid block size and orientation can be used [3]. Displacement along any streamline follows a one-dimensional solution with no