Study on combination boundary of permeability level difference and water injection intensity based on reservoir numerical simulation technology

Yongquan Zhou*

The second Oil Production Plant of Daqing Oilfield Co., LTD, Daqing 163000, China

Abstract. Series of strata combination in water drive for determining phase development, reservoir property and development parameters difference problems seriously affect the development effect, in order to reduce portfolio development difference between oil layers for the effects of the development in this paper, by using the method of numerical simulation, through the ECLIPSE numerical simulation software, 1 note 4 pick the ideal model is set up and simulated the process of production, To optimize the combined development of reservoir objects, to clarify the combined boundary of permeability level difference and water injection intensity, and to provide theoretical basis for guiding the selection of relevant parameters in the actual production of oil fields.

Key words: Permeability level difference water injection strength limit numerical simulation.

1. Introduction

Continental reservoir sedimentary oilfield waterflood development stage in determining more, due to the combined development of reservoir physical properties and development parameters difference influence on development effect is very obvious, the resulting combination development series of strata overall water cut rising speed, production decline rate, low recovery efficiency and inefficiency is invalid loop, and a series of serious problems also increasingly prominent [1-4]. Therefore, it is necessary to study the physical properties of reservoir and the boundary of development parameters. In this paper, ECLIPSE numerical simulation software is used to simulate the development process of oil reservoirs with different permeability levels and different water injection intensities. Statistical analysis is made on the simulated water cut and recovery factors, and the combined boundary of permeability levels and water injection intensities is given, which has guiding significance for the actual production of oil fields.

2. Modeling

In this paper, the injection-production unit model of one injection-production and four production with five-point area well pattern is adopted, and the injection-production well spacing is 250m. The model divides a 21×21 grid in the horizontal direction, and the grid step is 17.68m. See Figure 1 for the well location map. The formation and fluid parameters are: formation porosity of 25%, oil density of 865kg/m3, formation water density of 1000kg/m3, oil viscosity of 6mpa. s, formation water viscosity of 0.95 mpa. s, oil volume coefficient of 1.12, formation water volume coefficient of 1.

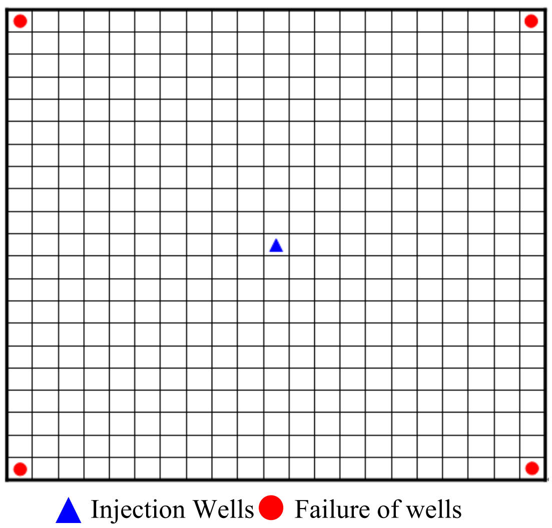


Fig. 1 Simulated well location map

3. Simulation schemes

The ideal model is used to simulate the production under the following conditions:
(1) The permeability of high permeability layer was fixed at 400×10-3μm3, and the permeability difference of low

* Corresponding author: 345245753@qq.com

permeability layer was changed to simulate the production process of well area under the premise of injection-production balance.

(2) the permeability of the simulated oil layer was fixed as 400×10-3μm3 or 100×10-3μm3, and the water injection intensity of one layer was fixed as 5m3/m.d. By changing the water injection intensity of the other layer, the water injection intensity multiple of the combined oil layer was changed to simulate the production process of the well area under the premise of injection-production balance.

4. Simulation results and discussion

4.1 Permeability differential boundary

Using scheme (1), the production process with 98% water cut in high permeability layer is simulated. As shown in Figure 2, with the increase of permeability level difference, the production situation of low permeability layer becomes worse gradually, and the recovery degree of composite layer decreases. When the permeability level difference is 5, the recovery degree of composite layer can be guaranteed above 43%. By figure 3, with increasing permeability differential, low permeability layer water gradually decline, and layer the change trend of water cut rise by falling before, analysis the reason, and water cut is high and low permeability layers produced fluid and water level, the differential permeability under 5, low permeability layer fluid producing proportion to maintain a certain level, the overall effect pull close layer water cut down; When the permeability level difference is greater than 5, the liquid production ratio of low permeability layer continues to decrease, while that of high permeability layer increases significantly, and the overall effect pulls the water cut of composite layer up. Therefore, it can be considered that the combination limit of permeability difference can be limited to 5 in order to ensure the development effect.

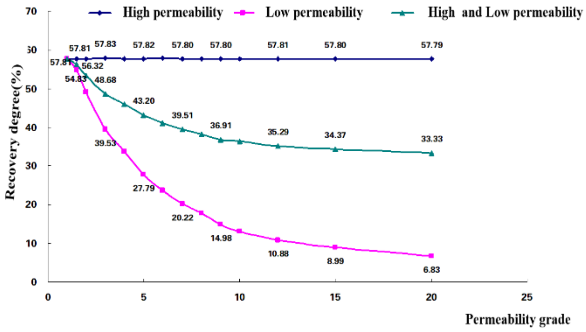


Fig. 2 Recovery degree affected by permeability difference

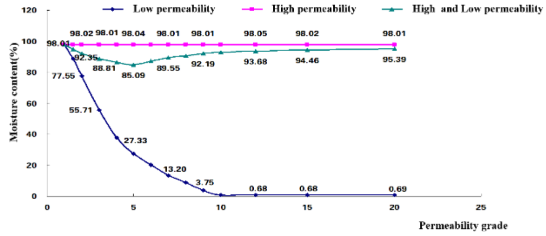


Fig. 3 Influence curve of water cut by permeability level difference

By using the permeability difference boundary of the combined development, the total water injection amount of each layer is simulated when the water cut of the whole well and the high permeability layer reaches 98%, which can quantitatively describe the low-efficiency circulation status of each small layer in the combined development reservoir. Through simulation, when the water cut of single-layer development reaches 98%, the injected water volume is 4-4.4PV. According to Figure 4, when the water cut of high permeability layer reaches 98% and the permeability level difference is 5, the volume of water injection in composite layer is 2.61PV, and that in low permeability layer is 0.78PV. As shown in Figure 5, when the water cut of composite layer reaches 98%, the increase of permeability level difference has relatively little influence on the injection volume of low permeability layer, and the low efficiency circulation of high permeability layer gradually increases. When the combination limit of permeability level difference 5 is reached, the injected water volume of high permeability layer is 11.17PV, and the low efficiency circulation volume is about 7PV. The volume of injected water in lamination is 6.76PV, and the low efficiency circulation is about 2PV.

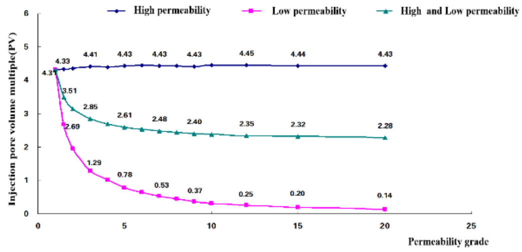


Fig. 4 Volume change curve of injected water with 98% water content in high permeability layer

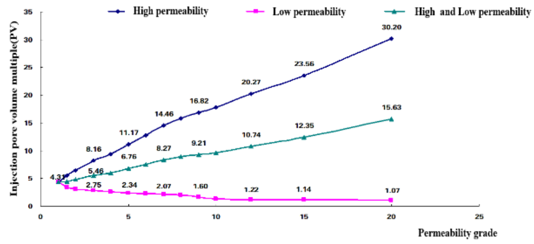
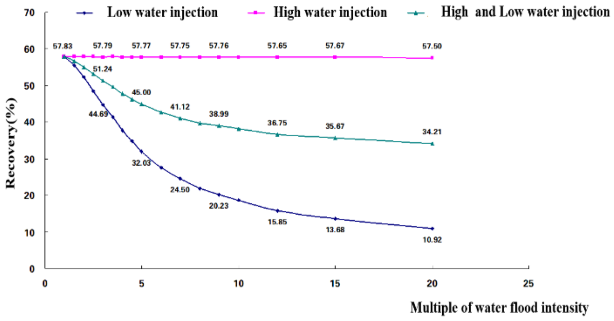


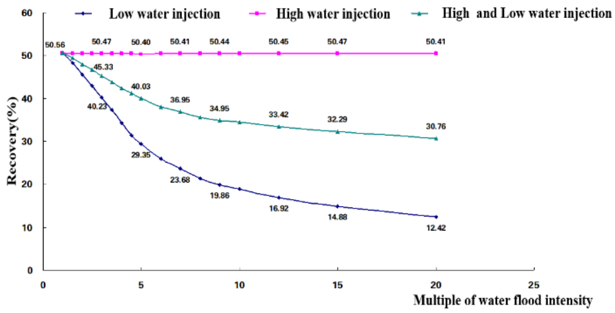
Fig. 5 Variation curve of injected water volume with 98% water content in composite layer

4.2 Combination limit of water injection intensity

The difference of water injection intensity is not only related to the permeability of the reservoir itself, but also to the connection relationship between oil and water well in the reservoir. In order to determine the combination limit of water injection intensity for the development of combined oil reservoirs, scheme (2) is used to simulate the production process with 98% water cut in high strength reservoirs. As shown in Figure 6, with the increase of water injection intensity multiple, the utilization of low strength layer gradually deteriorates, and the recovery degree of composite layer decreases. When the water injection intensity multiple is 5, the recovery degree of high permeability layer with 400×10-3μm3 and low permeability layer with 100×10-3μm3 can be guaranteed to be 45% and 40% respectively.



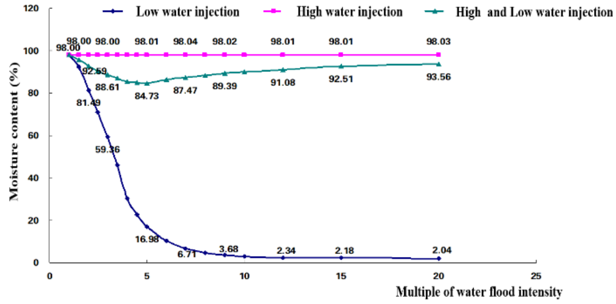
Permeability is 400×10^{-3}μm^3



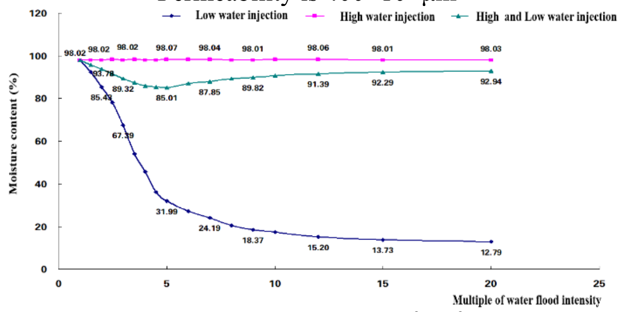
Permeability is 100×10^{-3}μm^3

Fig. 6 Recovery curve with water injection intensity multiple

From figure 7, water injection intensity ratio increase, water gradually decline, low intensity layer or layer the change trend of water cut rise by falling before, analysis the reason, layer water cut is high and low intensity produced fluid and water level, water injection strength ratio under 5, low intensity layer produced fluid proportion to maintain a certain level, the overall effect of pulling together layer water cut down; When the water injection intensity multiple is greater than 5, the liquid production ratio of the low strength layer continues to decrease, while that of the high strength layer increases significantly, and the overall effect pulls the water cut of the composite layer up. Therefore, in order to ensure the development effect, the combination limit of water injection intensity multiple can be limited to 5.



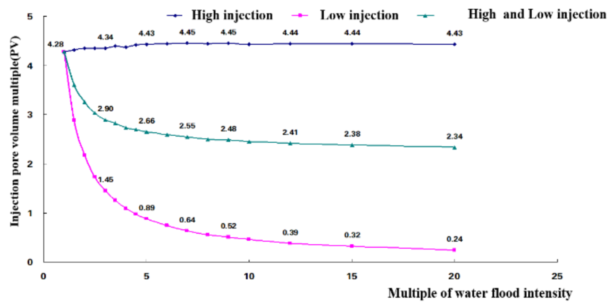
Permeability is 400×10^{-3}μm^3



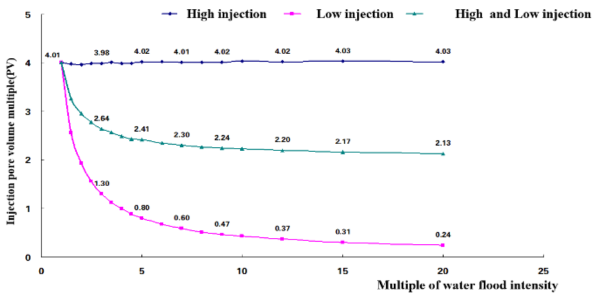
Permeability is 100×10^{-3}μm^3

Fig. 7 Variation curve of water cut with water injection intensity multiple

The water injection intensity multiple boundary of combined development can be used to simulate the total water injection amount of each layer when the water cut of the whole well and the high strength layer reaches 98%, which can quantitatively describe the low-efficiency circulation of each small layer in the combined development oil layer. According to Figure 8, when the water cut of 400×10-3μm3 high permeability layer and 100×10-3μm3 low permeability layer reaches 98%, the volume of injected water is 4.4PV and 4.0PV, respectively. When the combination limit of water injection intensity is 5, the volume of combined water injection is 2.6PV (high permeability layer) and 2.41PV (low permeability layer), respectively. The volume of water injected into low permeability layer is 0.89PV (high permeability layer) and 0.80PV (low permeability layer), respectively.



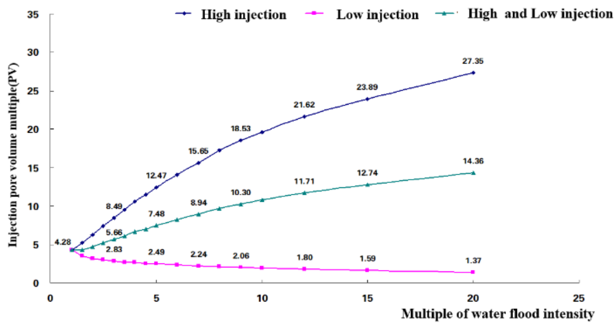
Permeability is 400×10^{-3}μm^3



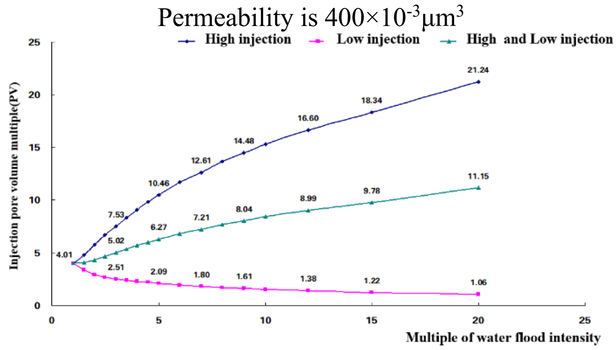
Permeability is $100 \times 10^{-3} \mu m^3$

Fig. 8 Volume change curve of injected water with 98% water content in high strength layer

According to Figure 9, when the water cut of composite layer reaches 98%, the increase of water injection intensity multiple has relatively little influence on the injection volume of low-strength layer, while the low-efficiency cycle of high-strength layer gradually increases. When the combination limit of water injection intensity 5 is reached, the total volume of water injection in high-permeability layer is 12.47PV (high-permeability layer) and 10.46 PV (low-permeability layer). The low efficiency circulation volume is 8.04PV (high permeability layer) and 6.44PV (low permeability layer), the total volume of combined layer water injection is 7.48PV (high permeability layer) and 6.27PV (low permeability layer), and the low efficiency circulation volume is 3.05PV (high permeability layer) and 2.25PV (low permeability layer).



Permeability is $400 \times 10^{-3} \mu m^3$



Permeability is $100 \times 10^{-3} \mu m^3$

Fig. 9 Volume change curve of injected water with 98% water content in composite layer

5. Conclusions and Cognition

(1) Use reservoir numerical simulation technology to simulate the production process of ideal model and summarize the boundary of reservoir physical properties and development parameter indexes for combined development, which has reference and guiding significance for parameter combination selection in actual production.
(2) The combination limit of permeability difference is determined as 5 through scheme simulation, at this time, the recovery degree of laminated layer is 43.20%, and the low efficiency circulation amount of laminated layer is 2PV.
(3) The limit of water injection intensity multiple was determined as 5 through scheme simulation. At this time, the simulated recovery degree of high permeability layer with permeability of 400×10-3μm3 was 45.00%, and the low efficiency circulation volume was 3.05PV. The simulated recovery degree of 100×10-3μm3 low permeability layer is 40.03%, and the low efficiency circulation volume is 2.25PV.

References

1. Liu He, Run Jianwen, Xue Fengyun et al. Research status and development direction of oil production engineering at extra high water cut stage in Daqing Oilfield. Petroleum Geology and Development in Daqing, 2004, vol.23 no.6
2. Zhao Shouyuan, Yang Yuzhe, JI Dechun. Several problems on adjustment of formation in high water cut stage of Daqing Oilfield. Acta Petrolei Sinica, 2005, vol.6 no. 4
3. Liu Jiyu, Liu Manyu, Xu Hao. Analysis and quantitative calculation of influencing factors of recovery degree in high water cut stage. Petroleum Geology and Recovery Efficiency, 2010, 17 (1)
4. Wei Changlin, Yuan Ye. Study on combination boundary of permeability difference based on reservoir numerical simulation technology. Science Technology and Engineering, vol. 11, No. 35, 2011