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An Improved Splitting Method of Liquid Production Within Thick Reservoir

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Abstract
Reasonable and accurate splitting method of liquid production is key to improve producing status of thick reservoir, but common methods at this stage are all kinds of problems such as limited accuracy, tedious process and workload issues, an improved splitting method of liquid production suitable for thick reservoir is necessary. Adjustment coefficient can be obtained from the regression and relevance between the fluid amount and parameters combined with reservoir monitoring data, core data and flooding information based on the splitting of liquid production in production and injection wells in order to split the fluid amount in different parts of thick reservoir. The improved splitting method of liquid production is proved to be accurate, reasonable, reliable and effective to improve the accuracy of the results of numerical simulation and guidance fine tapping of thick reservoir.

Key words: Splitting method of liquid production; Thick reservoir; Numerical simulation

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INTRODUCTION

The liquid volume splitting of production and injection wells is very important in reservoir performance analysis, reservoir use conditions and remaining oil distribution[1-3]. Formation coefficient, dynamic splitting and numerical simulation are main splitting methods of liquid production, to some extent these methods have characteristics of limited accuracy, tedious process and workload issues besides not suitable for thick reservoir[4-10]. Producing status is quite different within thick reservoir, and it's hard to split liquid production because single well production layer and injection-production relationship are complex. An improved splitting method of liquid production within thick reservoir is key to numerical simulation and necessary to improve the usage of thick reservoir.

1. THE DERIVATION OF AN IMPROVED SPLITTING METHOD OF LIQUID PRODUCTION WITHIN THICK RESERVOIR

1.1 The Fluid Volume Splitting Method of Production and Injection Wells

Water injection profile data can be used to split the liquid production of production and injection wells sedimentary units. Dynamic splitting equation is suitable for the injecting liquid production splitting of injection wells which are lack of water injection profile data.

$$Q_{wi} = Q_w \cdot \frac{KH_i \cdot M_i}{\sum_{i=1}^{n} KH_i \cdot M_i}. \tag{1}$$

M_i is measures transform coefficient which is determined by results of oil field reconstruction measures[11], M_i is equal to 2 for fracturing wells, M_i is equal to 1 for non-fracturing wells, and M_i is equal to 0 for plugging wells by statistical results of the reservoir.

Assign injection wells units amount to the surrounding production wells according to the development and connectivity of production wells.

$$Q_{oj} = Q_{wi} \cdot \frac{KH_j \cdot M_j \cdot Z_j / \ln D_j}{\sum_{j=1}^{n} KH_j \cdot M_j \cdot Z_j / \ln D_j}. \quad (2)$$

Z_j is connectivity coefficient which is determined by the connectivity of layers which can be calculated by numerical simulation[11], Z_j is equal to 1 for homogeneous reservoir. For heterogeneous reservoir, Z_j is equal to 1.3 when wells are in channel sands, Z_j is equal to 0.3 when there is small block between wells, Z_j is equal to 0 when degree of heterogeneity is too high.

The production fluid amount of production wells sedimentary units can be calculated by water injection amount calculation of injection wells around the production wells.

$$Q_{ok} = \sum_{k=1}^{n} Q_{oj}. \quad (3)$$

Correction must be taken by the actual amount of fluid.

$$Q_{ok}{}' = Q_o \cdot \frac{Q_{ok}}{\sum_{k=1}^{n} Q_{ok}}. \quad (4)$$

1.2 The Splitting of Liquid Production Within Thick Reservoir

Liquid production splitting correction coefficient is the deviation value between ratio of Liquid production and ratio of formation factor between local and global. Calculation equations can be derived from monitoring wells and layers data, and the correction coefficient can be calculated.

$$\sigma_i = \frac{Q_i \cdot \sum_{i=1}^{n} K_i \cdot \sum_{i=1}^{n} H_i}{n \cdot KH_i \cdot \sum_{i=1}^{n} Q_i}. \quad (5)$$

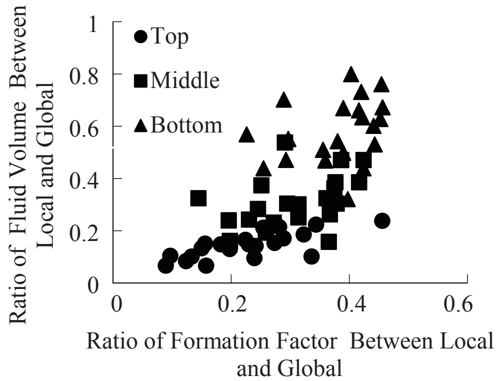

Figure 1 Correction Charts of Fluid Splitting in Monitoring Wells and Layers

Liquid production splitting correction coefficient can be calculated by the calculation model of production fluid strength coefficient which is needed to analyze the correlation between fluid amount and parameters in coring wells and layers.

$$\sigma_i = \frac{Y_{qi}}{K_i} = 16.767 \times \Phi - 7.569 \times V_{sh} - 0.513. \quad (6)$$

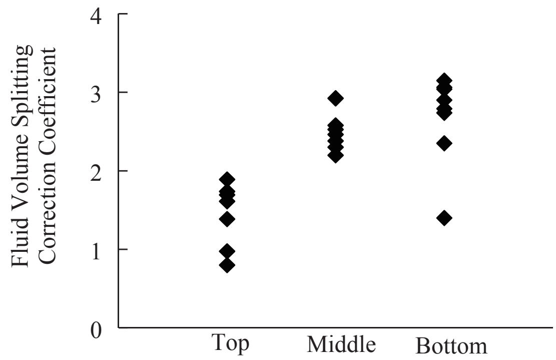

Figure 2 Correction Charts of Fluid Splitting in Coring Wells and Layers

Liquid production splitting correction coefficient can also be calculated by the calculation model of production fluid strength coefficient which is needed to analyze the correlation between fluid amount and parameters in water-flooded wells and layers.

$$\sigma_i = \frac{Y_{si}}{K_i} = 3.457^{\frac{S_w - S_{wi}}{1 - S_{wi}}}. \quad (7)$$

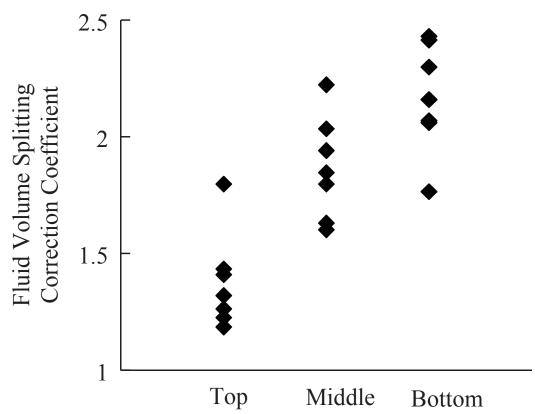

Figure 3 Correction Charts of Fluid Splitting in Water-Flooded Wells and Layers

Taking the bottom correction coefficient as standard, normalize liquid production splitting correction coefficient in different parts to get comprehensive correction coefficient. At last we get the liquid production splitting coefficient by weighting comprehensive correction coefficient with the formation factor.

$$C_i = \frac{KH_i \theta_i}{\sum_{i=1}^{n} KH_i \theta_i}. \quad (8)$$

2. THE VALIDATION OF THE SPLITTING METHOD AND APPLICATION EFFECT

2.1 Verification of the Liquid Production Splitting Method Rationality

Taking the Thick reservoir in LMD oilfield as an example, calculate the correction coefficient of different parts using the data of SIII6+7 unit of well L6-233 in district six of LMD west block.

Table 1
Correction Coefficients of Fluid Splitting Within the Layer

Part of the unit	Coring wells and layers	Water-flooded wells and layers	Monitoring wells and layers	Correction coefficient
Top	0.671	0.662	0.635	0.656
Middle	0.883	0.825	0.851	0.853
Bottom	1	1	1	1

The contrast results show that the splitting of liquid production is reasonable.

Table 2
Comparison of Water Injection Profile and Fluid Splitting Coefficients

Part of the unit	Water injection profile				Correction coefficient /%
	2006 /%	2008 /%	2011 /%	Mean /%	
Top	30.5	36.2	40.3	35.7	36.1
Middle	20.9	18.1	16.6	18.5	18.7
Bottom	48.6	45.7	43.1	45.8	45.2

Oil displacement efficiency of different parts of SIII6+7 unit can be calculated by C-type water-flooding curve which can be plotted by the split liquid production, error is small as 0.83% comparison with coring wells and layers data, so the splitting method of liquid production is scientific and reasonable.

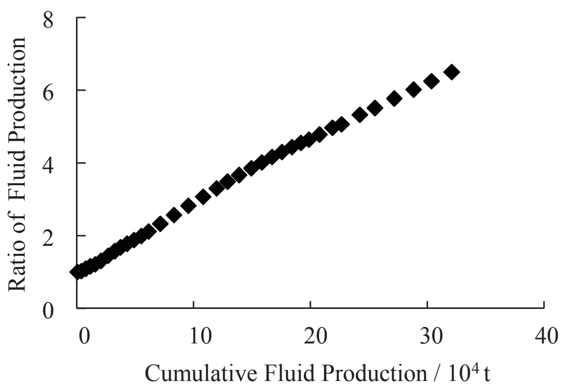

Figure 4
C-Type Water-Flooding Curve of Splitted Fluid in the Upper Unit

Table 3
Oil Displacement Efficiency Comparison of Splitted Fluid and Coring Wells Data

Part of the unit	Oil displacement efficiency/%		Error/%
	Coring wells and layers data	The splitting of liquid production data	
Top	48.9	48.27	-1.29
Middle	50.6	52.64	4.03
Bottom	53.4	52.41	-1.85
Total	51.7	51.27	-0.83

2.2 Application Effect

Well L6-201 is located at typical Thick reservoir block in LMD oilfield, and Layer SIII6+7 is a typical thick oil layer.

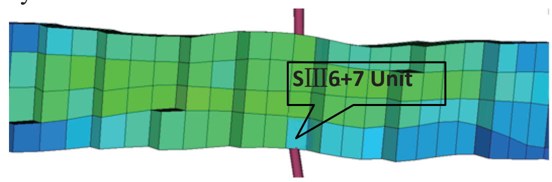

Figure 5
Well Intersection View of Numerical Simulation Model Based on Non-Splitted Fluid

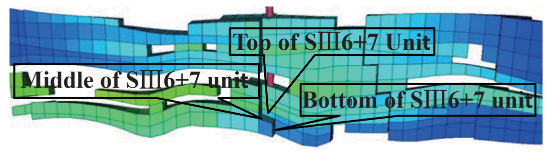

Figure 6
Well Intersection View of Numerical Simulation Model Based on Splitted Fluid

Well Intersection view of numerical simulation model based on non-splitted fluid and splitted fluid shows that mathematical simulation model based on splitted fluid is more realistic. Daily liquid production and water of the bottom of the unit decrease after the splitting of liquid production, and liquid production and comprehensive water of the well improve. Numerical simulation based on the splitting method of liquid production achieve good application effect.

CONCLUSION

(1) Analyzing the correlation between fluid amount and parameters in monitoring, coring wells and layers and water-flooded data, draw fluid splitting correction charts of different parts within thick layers as to get the correction coefficient. Weight comprehensive correction coefficient with the formation factor to get the liquid production splitting coefficient to fine split the liquid production within thick layers.

(2) The splitting method of liquid production can effectively improve the accuracy of the results of the numerical simulation, and it has a very important role in guiding fine adjust of tapping and improving the producing condition of thick reserviors.

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