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The Research of Remaining Oil in the Third Southern District by using Numerical Simulation

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Abstract: In order to determine the injection parameters of class Ⅱreservoir, according to the laboratory physical simulation experiments, numerical simulation and analysis of field data, study the geological features, sedimentary characteristics, polymer injection object of class Ⅱreservoir in the middle of the third southern district, conduct a series of pilot field tests of polymer injection. Through mathematical modeling and history matching method, study the displacement effect influenced by polymer molecular weight, polymer concentration, slug size and injection speed. The results show that class Ⅱreservoir in the middle of the third southern district can be configured and diluted with water. The molecular weight is 700-950 ten thousand, the concentration is 1100mg / L, the injection speed is 0.2PV/a, the injection slug is 0.64PV.
Keywords: class Ⅱreservoir, polymer flooding, injection parameters

INTRODUCTION

Structural model is the basis of geological modeling [1]. It reflects the reservoir's space framework and is a comprehensive reflection of geological structural features and characteristics of the department of small layers. It is composed of fault rupture model and level model. Utilizing the three-dimensional visualization functions of modeling software, data of 138 small layers in the whole region is proofread to ensure the accuracy of modeling. When displaying the data points in the same small layer group of top surface in the three-dimensional space, it should be an anticlinal structure distribution theoretically. If the individual data point is far away from the trend surface of anticline structure, it is considered to be abnormal data points. These anomalies are mainly generated in the process of stratigraphic correlation and database establishment as well as data collation.

Considering the structural features, source direction [3], location and other conditions of the well group and minimizing grid nodes, numerical simulation grid system of the block is established. In the horizontal plane, the model adopts 20 × 20m grid and determines that the X direction is divided 65 grids, Y direction is divided 53 grids. The grid is substantially uniform rectangular corner point grid. Vertically, take the contrasted small layer as the main. The reservoir is divided into 138

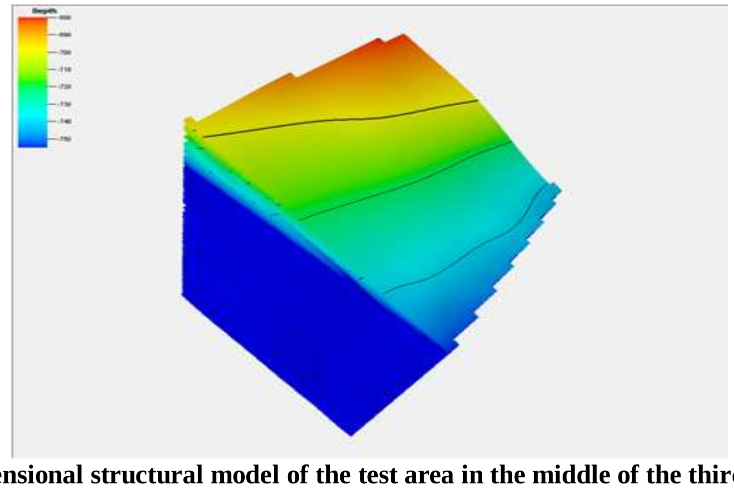

Fig-1: Three-dimensional structural model of the test area in the middle of the third southern district

WATER FLOODING AND THE DISTRIBUTION OF REMAINING OIL OF THE TEST AREA IN THE MIDDLE OF THE THIRD SOUTHERN DISTRICT

History matching is to use the existing reservoir parameters to calculate the development history of oilfield [2]. And compare the calculation of development indexes such as pressure, yield and water content and the actual dynamic of field development. If the calculation result is inconsistent with the actual, then the knowledge of the oilfield is unclear. The input parameters and ground conditions don't meet. Appropriate adjustments must be made and then modify and calculate until the calculation result and the actual dynamic are consistent or within the allowable range. Such reservoir model created can reflect the actual situation of reservoir. History matching is a process which needs modifying and calculating repeatedly. In the process of history matching, we need to fit the formation pressure, composite water cut, single well water cut, liquid production, degree of reserve recovery and so on. History matching is a very important role in simulation experiment and is the basis of dynamic prediction of oilfield development.

Table-1: Fitting reserve statement of the middle of the third southern district

Fitting geological reserves (Ten thousand tons)	geological reserves (Ten thousand tons)	Fitting error (%)
722.15	718.73	0.69

By modifying the reservoir porosity, effective thickness and other parameters field, the calculated reserves for numerical simulation is fitted based on the submitted geological proved reserves. Fitting geological reserves is 7,267,800 tons, and geological reserves of the middle of the third southern district is 7,187,300 tons. Fitting error of the whole reservoir's reserves is 0.69%, which is in line with industry standards. This shows that the geological model is more reliable and an be used as basis for history matching and later dynamic prediction.

Fitting the stage of water flooding of the test area

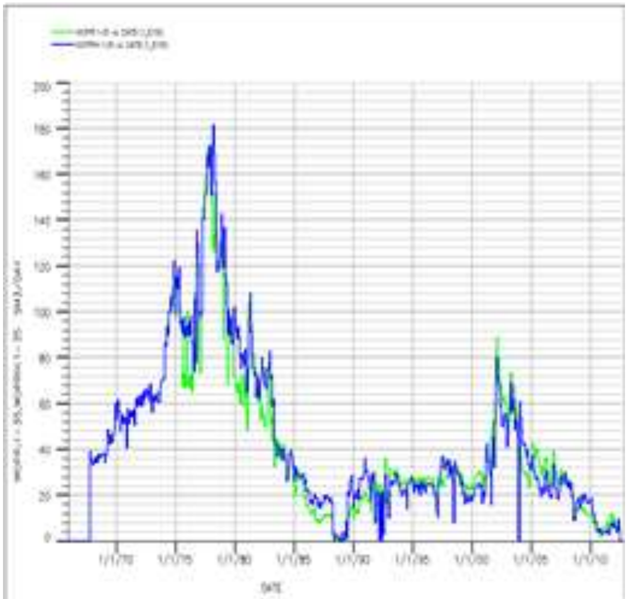

Fig-2: Fitting curve of daily oil production of N3-1-35

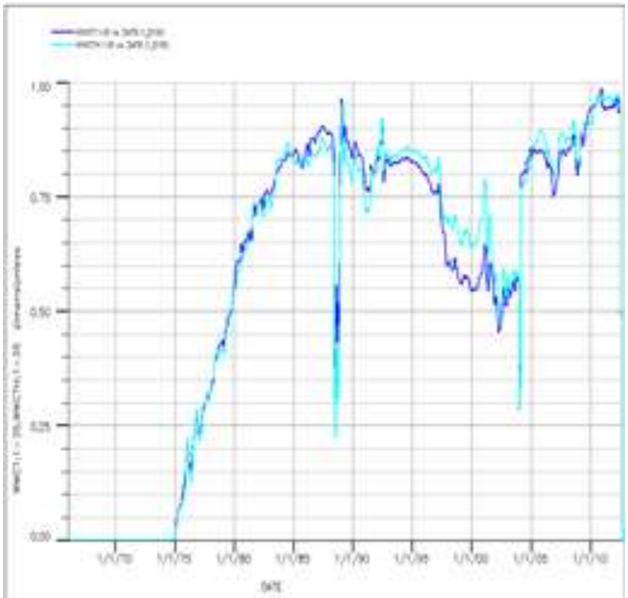

Fig-3: Fitting curve of water content of N3-1-35

POLYMER INJECTION PARAMETER OPTIMIZATION OF THE PURPOSE LAYER OF THE TEST AREA IN THE MIDDLE OF THE THIRD SOUTHERN DISTRICT

At present, the integrated water content of the purpose layer of the test area in the middle of the third southern district is 87.24% and in the high water exploitation stage. The effective thickness of PuI5-7 ~PuII1-3 reservoirs flooding is of high proportion. Continuing to water flooding is more and more difficult but the economic benefit of water flooding development is poor. According to the knowledge gained in Daqing oilfield and other test block, this kind of reservoir still has larger potential of high concentrations after water flooding. Therefore carry a high concentration of polymer flooding simulation studies, high concentrations of polymer flooding injection parameter optimization, scheme optimization and evaluation of the effect to provide theoretical guidance for the high concentrations of polymer flooding field tests.

Table-2: The numerical simulation results of polymer molecular weight in test area

Polymer molecular weight	Cumulative oil production	The degree of stage recovery	Increase value of recovery ratio	Minimum water content value	Injection speed
Ten Thousand	($\times 10^4$t)	(%)	(%)	(%)	(PV/a)
500-700	2.90	15.45	7.69	84.11	0.2
700-950	2.92	15.55	7.79	84.21	0.2
950-1200	2.95	15.74	7.98	83.00	0.2
1200-1600	2.98	15.88	8.12	81.90	0.2

Polymer injection program: When the parameters selection of polymer is that the concentration is 1000mg/L, the slug is 0.6PV and the injection speed is 0.2PV/a, study the polymer flooding effect that polymer molecular weights are 1200-1600, 950-1200,700-950, 500-700 ten thousand.

Polymer injection program: When the parameters selection of polymer is that the polymer molecular weight is 700-950 ten thousand, the slug is 0.6PV and the injection speed is 0.2PV/a, study the polymer flooding effect that concentrations are 800mg/L, 900mg/L, 1000mg/L, 1100mg/L, 1200mg/L, 1300mg/L.

A lot of previous research results show that: with the increasing slug concentration of injection polymer, the ultimate recovery of polymer flooding increases, the decrease level of water content increases and the water savings increase. By numerical simulation calculation of different concentration of polymer flooding project under the condition that polymer molecular weight is 700~950 million, the injection speed is 0.2PV/a, the results also illustrate this point.

Table-3: The numerical simulation results of polymer concentration in test area

Polymer concentration	Cumulative oil production	The degree of stage recovery	Increase value of recovery ratio	Minimum water content value	Injection speed
(mg/L)	($\times 10^4$t)	(%)	(%)	(%)	(PV/a)
800	2.87	15.30	7.54	85.78	0.2
900	2.90	15.43	7.67	84.94	0.2
1000	2.92	15.55	7.79	84.21	0.2
1100	2.96	15.76	8.00	82.82	0.2
1200	2.98	15.89	8.13	81.82	0.2
1300	2.96	15.76	8.00	81.38	0.2

By analyzing the numerical simulation results we know: from the point of view of cumulative oil production, when the concentration is 1200mg/L, the cumulative oil production reaches 29800 tons. From the water content, when the concentration is 1200mg/L the lowest water content value is 81.82%. From the recovery ratio, when the concentration is 1100mg/L the value is 0.21% and is the maximum magnitude. Considering these factors, when the polymer concentration is considered 1000mg/L-1200 mg / L the effect is the best.

Polymer injection program: When the parameters selection of polymer is that the polymer molecular weight is 700-950 ten thousand, the concentration is 1100mg/L and the injection speed is 0.2PV/a, study the polymer flooding effect that polymer slugs are 0.5PV, 0.57PV, 0.6PV, 0.64PV, 0.7PV.

Numerical simulation of the test area is calculated under the conditions of different polymer slug size, the results are shown below. Control the injection speed as 0.2PV / a, polymer molecular weight as 700 to 950 ten thousand, the polymer concentration as 1100 mg / L. Polymer slug sizes differ, namely polymer injection time is different. The results can be seen from the table that the size of polymer slug affects cumulative oil production of test area.

Table-4: The simulation results of polymer slug size

Polymer slug	Injection speed	Polymer injection time	Cumulative oil production	The degree of stage recovery	Increasing value of recovery rate	Minimum water content values
(PV)	(PV/a)	(year)	($\times 10^4$t)	(%)	(%)	(%)
0.5	0.2	2.5	2.91	15.53	7.77	82.82
0.57	0.2	2.85	2.94	15.69	7.93	82.82
0.6	0.2	3	2.94	15.69	7.93	82.82
0.64	0.2	3.2	2.97	15.84	8.08	82.82
0.7	0.2	3.5	3.00	15.98	8.22	82.82

From the water content, the larger the polymer slug, the larger the decrease level of water content. Calculated moisture contents under different conditions of polymer slug size reach the lowest value 82.82% at the same time. After that the water content increases and the bigger the slug, the slower the rise speed, the lower the water cut, but the difference is not significant. From the degree of stage recovery, the greater the injection polymer slug, the higher the degree of stage recovery. From the increasing level of the degree of stage recovery, the largest level is the polymer slug size of 0.64PV, and the smallest level is the polymer slug size of 0.7PV. Thus, the optimization of polymer slug is mainly from two aspects to consider, namely the polymer slug impact on the moisture content and increasing level of the degree of stage recovery. According to the simulation results, recommend the 0.57-0.64PV as the best polymer slug.

Polymer injection program: When the parameters selection of polymer is that the polymer molecular weight is 700-950 ten thousand, the concentration is 1100mg/L and the polymer slug is 0.64PV, study the polymer flooding effect that polymer injection speeds are 0.1PV / a, 0.15PV / a, 0.2PV / a, 0.25PV / a, 0.3PV / a.

Use numerical simulation to calculate the polymer flooding program of different polymer injection rate, and the results are shown in table. As can be seen from the table, the injection speed has a great impact on the ultimate recovery. However, the higher polymer injection speed, the higher the corresponding formation pressure and the greater the corresponding injection pressure difference. In addition, the injection rate is also affected by the physical properties of the reservoir and the injection well spacing and other factors, therefore, the choice of the polymer injection rate should consolidate field test and various parameters. Polymer injection parameters: molecular weight of 700 to 950 ten thousand, the concentration of 1100mg / L, injection slug of 0.64PV.

Table-5: The numerical simulation results of polymer injection speed

Polymer injection speed	Cumulative oil production	The degree of stage recovery	Increasing value of recovery rate	Minimum water content value
(PV/a)	($\times 10^4$t)	(%)	(%)	(%)
0.1	2.90	15.44	7.68	82.03
0.15	2.96	15.74	7.98	82.61
0.2	2.97	15.84	8.08	82.82
0.25	2.67	14.22	6.46	83.00
0.3	2.71	14.45	6.69	83.87

CONCLUSIONS

Optimize injection parameters of polymer flooding water configuration and dilution. The optimal solution of water configuration and dilution is: the molecular weight is 700-950 ten thousand, the concentration is 1100mg / L, the injection speed is 0.2PV/a, the injection slug is 0.64PV.

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