Fixed point continuous monitoring system of oilfield skeleton and its application

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Abstract: Aiming at fixed monitoring well point in oil field monitoring deployment chaotic, block monitoring percentage change is big, suitable for lack of contrast data, and poor adaptability to changes in the cost problem, plane layout, well pattern deployment, give attention to two or morethings injection-production differences, etc., to determine the skeleton designated strip continuous monitoring, use the statistical methods such as cluster analysis, deep learning, combining with the field dynamic data changes, To optimize the deployment of well points, determine the principle of "skeleton well fixed continuous monitoring, non-skeleton well according to demand", establish skeleton fixed continuous monitoring system, achieve the purpose of saving monitoring costs and improving the accuracy of reservoir evaluation. Research results show that the skeleton fixed-point continuous monitoring system to meet the needs of overall reservoir evaluation, more through rules deployment of a certain percentage of the skeleton well point and the fixed location monitoring of the stability can be compared to the continuity of the data, ensure the evaluation precision reservoir framework, at the same time using the non-framework change monitoring well balance monitoring proportion, key and the key blocks of costs change with a strong adaptability. Through research and field practice, it has been proved that the skeleton fixed-point continuous monitoring system combines oilfield monitoring deployment with traditional geological profile analysis mode, and realizes the fusion application of three system frameworks: dynamic monitoring, geological static and numerical simulation, which is helpful to promote the process of precise grid management of reservoir.

Key words: Skeleton monitoring; Fixed point continuity; Cluster analysis; Monitoring ratio; Well point selection.

1. Introduction

According to the Outline of Oilfield Development Management of CNPC, the dynamic monitoring of oilfield development should follow the design scheme of development unit, and the number of monitored Wells should meet the requirements of reservoir development dynamic analysis as the principle. In accordance with the principle of point-surface combination and highlighting key points, the general and typical blocks are combined, and the fixed and non-fixed well points are combined. The selection of monitoring well sites should be representative and continuous. The traditional monitoring system gives priority to meet the needs of adjustment, the fixed monitoring well points are disordered, the monitoring proportion of each block changes greatly, the applicable continuous contrast data is insufficient, and the application level of results is poor, which cannot meet the needs of the overall reservoir evaluation. With the deepening of oilfield development, the distance between injection and production Wells decreases and the density of well pattern increases gradually. The monitoring system is difficult to adapt to the dual restrictions of monitoring ratio and cost, which increases the difficulty of monitoring deployment. Since the "13th Five-Year Plan", the concept of oilfield development has changed from fine to precise. It is necessary to integrate monitoring results with other types of data more closely, and carry out accurate evaluation of reservoir production from whole to local, macro to micro [1-4]. Based on the above requirements, the framework fixed-point continuous monitoring system was built, which fully considered the representativeness and continuity of monitoring well points, combined point and surface, highlighted key points, and accurately reflected the reservoir development situation.

2. Determine the framework of continuous monitoring system

In hydrogeology, Marine geology and other observation work [5], some key locations are often selected for fixed-point continuous observation to meet the overall evaluation and continuous comparative analysis of data.

With the deepening of the grid management reform of the social governance system, the advantages of management methods are gradually highlighted. Therefore, the two modes should be integrated into oilfield monitoring work to promote grid management of oilfield monitoring, adapt to cost changes and meet development needs.

The basic well pattern deployment in the old area of Daqing Placanticline adopts the row and row cutting mode, that is, three rows of oil Wells are deployed in the middle of two rows of Wells, so that the horizontal and longitudinal well arrangement mode is mostly used in the later oil-wells deployment in the pure oil area, which also promotes the fine division of blocks and the construction of multi-turn infill well pattern to take well arrangement as the boundary. Based on the principle of considering plane layout, well pattern deployment and regional injection and production differences, the relationship between overall deployment and unit management is balanced, and the skeleton strip is established: horizontal well row is the base oil well row, vertical uniform coverage is given priority, and all well patterns are deployed, and the width refers to the common multiple of well spacing.

By comparing the relationship between the number of skeleton Wells and the total number of Wells with historical data, the proportion of skeleton Wells is always stable. Therefore, the continuous monitoring and interpretation results of skeleton well points can characterize the overall development situation of the reservoir to a certain extent.

3. Determine the reasonable monitoring proportion within the framework

The framework fixed-point continuous monitoring system should not only ensure the orderly and continuous monitoring of skeleton Wells, but also keep the reasonable monitoring proportion of skeleton Wells and ensure the accuracy of reservoir evaluation framework. Therefore, it is very important to clarify the reasonable monitoring proportion in the framework for system construction.

3.1 Cluster analysis method [6]

Center clustering method is a common algorithm in cluster analysis. It takes finding the center of each cluster as the basic task, and classifies the points in a certain range into the center cluster. K-means algorithm is one of the representative algorithms of center clustering. It takes the iteration process as the main line and the positive integer K as the hyperparameter, and updates the centers of K cluster classes in each turn. For the sample set in a given space, the initial center points of K family clusters are selected randomly or with input sample features. Then, in each iteration process, the distance between samples and related centers is calculated and classified into the nearest class cluster. After the new class cluster is obtained, the sample average value is calculated, which is used as the next iteration center to continue the calculation, and then the sample category division is realized.

3.2 Determine the reasonable monitoring proportion

Daqing changyuan old USES encryption rounds on gradually in-depth development of the reservoir development technology, each set of well pattern development objects intertwined overlap, plus local horizon seal oil and water Wells, take the set of methods of uniform distribution pattern already can't satisfy the needs of representative, therefore decided to adopt the method of clustering center, to belong to cluster the oil and water Wells.

（1）Single well feature scoring method [7]

Oil Wells can be divided into underground reservoir, wellbore structure, three components of the ground parameters, the use of these factors affecting on liquid water injection and production capacity for each hit a comprehensive score well, that is, from all kinds of attribute data for public factor, when the common factor contribution rate reaches a certain level, the composite scores represent the characteristics of oil and water Wells. The spatial correlation structure of all injection Wells can be obtained by using the single well score and well location coordinates, and the Wells with similar structures can be grouped into the same cluster.

（2）Determine the reasonable monitoring proportion

The interpolation error of each class cluster is obtained according to the variational function of single well score, well location coordinates and Kriging interpolation. The number of sample class clusters is drained according to a certain rule, and the mean square deviation of class cluster value is calculated. The curve of attribute change rate with proportion of well number can be drawn.

Table 1 Some data after cluster analysis and calculation

Class number of clusters	proportion (%)	clustering	
		Mean square error	Degrees of freedom
38	5%	7.807	37
76	10%	3.855	75
114	15%	2.559	113
153	20%	1.903	152
191	25%	1.522	190
229	30%	1.268	228
267	35%	1.087	266
305	40%	0.951	304
343	45%	0.846	342
382	50%	0.759	381
420	55%	0.690	419
458	60%	0.633	457
496	65%	0.584	495
534	70%	0.543	533
572	75%	0.506	571
610	80%	0.475	609
649	85%	0.446	648
687	90%	0.422	686
725	95%	0.399	724
763	100%	0.38	762

As can be seen from the curve, with the continuous improvement of the monitoring proportion, the slope of the curve gradually decreases and tends to be stable. The mean square deviation 1.5 is taken as the limit, and the reasonable monitoring proportion of the clear block is 25%-35%. The reasonable monitoring density of different blocks is different, and the monitoring density of skeleton bands in different blocks should also be differentiated. Therefore, the proportion of fixed-point continuous monitoring of skeleton strip should be consistent with the reasonable monitoring proportion of the block, and the monitoring proportion of non-skeleton well and skeleton non-fixed-point well should be adjusted to adapt to the change of monitoring cost.

4. Determine the method of monitoring well site selection within the framework

According to the principle of cluster analysis, the number of monitored Wells can be clarified, but the well points with the most monitoring value in the cluster cannot be selected. Therefore, the local injection-production relationship should be given priority in the selection process of monitoring well points to meet the needs of dynamic adjustment.

4.1 Selection method of injection profile logging well point

The MONITORING WELL point OF injection profile SHOULD be THE WELL with strong water injection sensitivity and great influence on the surrounding oil Wells. Therefore, the deployment of monitoring well point should be optimized from this perspective. The factors that determine the production are related to the distribution of reservoir physical parameters, reservoir fluid characteristics, well pattern forms and injection-production parameters. All parameters have complex historical dependence, so convolutional neural network (CNN) is suitable to solve this problem [8].

Based ON THE HISTORICAL PRODUCTION DATA, A single WELL history FITTING model IS established with an oil well as the center. By changing the water injection volume of an injection well, the oil well production changes are induced and the oil-well connectivity relationship is determined.

When the water injection volume of a well changes and the oil well production changes greatly, the water injection sensitivity of the well is strong. Based on the comprehensive judgment of oil and Wells in each cluster area and the influence of injection Wells on oil Wells in this cluster area, the water injection sensitivity of injection Wells in the region is ranked, the priority of injection profile monitoring is clarified, and the skeleton fixed point of continuous monitoring well point is determined. Due to the variation of dynamic parameters, the calculation result is short-term, so it needs to be recalculated every year to obtain a new sensitive sequence to guide the change of non-skeleton well monitoring deployment.

4.2 Well point selection method for well test monitoring

Injection-production ratio is one of the main influencing factors of formation pressure variation, which reflects the change of injection-production ends. Therefore, the concept of apparent injection-production ratio is used to evaluate the regional extent of the same cluster to measure the deployment and turnover of monitoring well sites.

Based on the classification results of different clusters obtained from cluster analysis, the concept of quasi-deviation of apparent injection-production ratio was introduced to calculate the apparent injection-production ratio of a single cluster, and the standard deviation of apparent injection-production ratio within the block was calculated. As a function of the number of class clusters, it is found that when the classification proportion reaches a certain degree, the variation range of standard deviation gradually decreases, which means that it has little influence on the representation of the overall pressure law of the block, so the monitoring proportion can be further optimized.

Theoretically, the central well within each type of cluster is regarded as a typical oil well, and the monitoring result represents the bottom pressure value of this type of cluster. However, due to the extensibility of oil reservoir properties and the timeliness of dynamic parameters, it is necessary to formulate the change mechanism of monitoring well:

I. The pressure measuring point should be set at the critical point because the injection-production ratio in the adjacent area is significantly different; If similar, it can reduce the number of manometric well points.

II. Pressure measuring well points should be added in areas with abnormal injection-production ratio; The monitoring well point can be reduced appropriately according to the injection production ratio area.

5. Examples of application

Based on the above methods, A skeleton fixed-point continuous monitoring system was established, which was exploratory applied in A development zone of Daqing Oilfield. The injection profile monitoring ratio and well test monitoring ratio were kept at about 27% and 12%, both lower than the planned ratio of 5%.

The PRACTICAL APPLICATION SHOWS THAT THE RESULTS OBTAINED FROM THE monitoring deployment meet the demand of block development and adjustment, and the utilization rate of data directly applied to injection-production adjustment keeps above 70%. At the same time, this method can further integrate monitoring deployment with geological framework model and digital modeling framework model, break through the traditional monitoring mode, combine with geological profile analysis, accurate digital modeling results, and further improve the accuracy of reservoir evaluation.

6. Conclusion

(1) The fixed-point continuous monitoring system of oilfield skeleton adopts big data statistical algorithms such as cluster analysis and convolutional nerve to start from the macroscopic deployment of oilfield monitoring, meet the principles of "Outline of Oilfield Development Management", and optimize the monitoring well points.
(2) Reservoir evaluation is an important basis for oilfield development adjustment, and monitoring data is one of the main factors affecting the evaluation results. Therefore, monitoring deployment should not only meet the daily production requirements, but also lay the foundation for accurate reservoir evaluation.
(3) Combined with the fixed-point continuous monitoring system of oilfield skeleton and the development adjustment needs, the evaluation data body should be further enriched, the evaluation method should be improved, and a set of integrated development monitoring and evaluation technology system should be established to adapt to the evaluation of reservoirs in the late stage of ultra-high water cut and accurately tap potential.

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