An intelligent dynamic analysis system for oil and gas reservoirs based on custom components

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Abstract. This paper introduces an intelligent dynamic analysis system of reservoir with components. The system has 6 modules: production early warning, report analysis, single well dynamic analysis, injection-production well group dynamic analysis, reservoir dynamic analysis, and intelligent knowledge base. The system data comes from the production data lake, monitors the production status of the reservoir in real time, and uses the conventional production warning and big data analysis warning to report the warning to users. Researchers can use the system's three-stage dynamic analysis module to process and resolve the corresponding warning information to maintain the normal production of the field. The system adopts component development, divides the commonly used algorithms and drawings for reservoir dynamic analysis into three categories of components. Each component can be independently applied to a specific scenario by connecting to the database. Through the configuration of free page XML, each component can quickly form different analysis scenarios in an adaptive way, so as to meet the complex and changeable requirements of reservoir geology and production, and better help oil field enterprises to reduce cost and increase efficiency.

1. Introduction
With the continuous development of information technology, the development performance system of oil and gas reservoir develops from the artificial experience method to the intelligent one. It is necessary to establish an intelligent working platform of "intelligent dynamic analysis system of oil and gas reservoir". Based on the professional data of petroleum geology, development and production, production test and other professional data, oilfield development dynamic analysis is a very complex system engineering, which is based on reservoir engineering, in accordance with relevant standards and specifications, combined with reservoir geological maps, to carry out statistical analysis, prediction, implementation, tracking and effect evaluation of development and production index dynamic information. The intelligent dynamic analysis system of oil and gas reservoir can help professionals better, faster, deeper and more systematic understand objects, find problems, analyze causes, find root
causes, and explore solutions to contradictions. The system adopts the idea of "high cohesion and low coupling", [2] clusters and distinguishes the commonly used indicators, maps and reports in the field of dynamic analysis of oil and gas reservoirs and decomposes them into different services according to different business scenarios and requirements. According to the actual needs, the system can quickly match the adaptive files to solve different business problems. This kind of intelligent dynamic analysis system of oil and gas reservoir is of component type and assembly type, which improves the flexibility of previous dynamic analysis system and is of great help to the study of complex oil and gas reservoirs.

As shown in Fig. 1, based on the long-term accumulated experience and analysis standards of oilfield workers, the commonly used dynamic analysis methods are combined in the form of "parallel connection", which changes the previous "series" analysis mechanism and shortens the time consumption of dynamic analysis. In this way, the dynamic analysis can be standardized so that researchers can get high-quality analysis results in the case of insufficient knowledge reserve.

Figure 1: The system explains the improvement of current dynamic analysis method.

Figure 2: System Architecture Description.

2. system design principle
Because reservoir performance analysis needs a large number of professional graphics display and frequent interaction in the field of petroleum engineering. Researchers have strong demand for graphics response speed and template customization, so it is difficult to achieve native B/S architecture. At present, the main application of B/S architecture is data display. Due to the limitation of browser, it does not support rich interactive operation well. In the past ten years, there were few pure B/S architecture professional applications with real significance. The compromise method was active graphics plug-in and Flash Plug-in developed by C sharp or C++ language. However, as modern browsers such as chrome, Firefox and edga have improved their security level and do not support plug-ins, the development method of plug-ins will be less and less. As shown in Fig. 2, the kernel of the system adopts C++ mapping algorithm, the data analysis method is written in C++ language, and the graphical interface is
written in C sharp. The bottom layer can call webservice service to realize data access. The middle layer is integrated with professional graphic components, and the presentation layer is developed by C sharp window.

3. Main function description

The production early warning module uses two kinds of algorithms: empirical method and data analysis method. The empirical method is based on the experience accumulated in the process of reservoir production and operation. The specific process is as follows: The user can freely select the production index, technical index and evaluation index provided by the system according to the reservoir characteristics, including 10 production indexes, 8 technical indexes and 4 evaluation indexes. Enter the threshold interval of the indicator according to the time point or time period. Specify the logical relationship of the selected indicators, including greater than, equal to, less than, or, and. Specify the alert level to which the indicator logical relationship points.

The system defaults to three levels of alert. After all the settings are completed, click single well early warning calculation, injection production well group early warning calculation and reservoir early warning calculation to get the early warning data table of single well, injection production well group and reservoir as a whole. The table includes production early warning result table, early warning summary table, early warning reservoir parameter tracking table, early warning result change table and dynamic change well treatment tracking table. At the same time, the warning results will also be reflected in the mining status map. The early warning results are classified, which is just consistent with the three-level dynamic analysis. Therefore, according to different early warning results, you can directly enter the corresponding dynamic analysis interface to complete the processing of the alarm situation.

Figure 3 Classification of production algorithms.

As shown in Fig. 3, the data analysis alarm module is divided into index parameter correlation analysis and algorithm module. The main function is to automatically select the indicators with high correlation with the target stratum, and then calculate the correlation between the indicators through the data algorithm and establish the discriminant equation. The discriminant equation is stored in the algorithm module of the intelligent knowledge base. When the warning results deviate, the output results of the model can be manually updated and saved back to the intelligent knowledge base. The pre-set correlation algorithms include: one variable nonlinear correlation, the best nonlinear fitting function, stepwise regression attribute optimization, and the optimal number of attributes. The algorithm includes: linear regression, multiple nonlinear regression, probabilistic neural network, projection classification template, BP neural network, analytic hierarchy process. [3]
The system preset single well dynamic analysis can draw the production data of the produced wells in the database into curves or charts, providing basis for reasonable analysis. Through the analysis of curves and charts, the production change of the production wells is determined. The production performance table of production well, production performance table of water injection well and connection diagram of oil and water wells are analyzed to maintain normal connection of oil and water wells and form uniform water line. By comparing the changes of indexes, the causes of the changes are analyzed, the results of production decline are analyzed, and the obvious decline of production and the rapid rise of water cut in the production wells are analyzed. This paper analyzes the daily production fluctuation of the produced well, determines the change of the production status of the oil well with the help of the data of adjacent wells in the same layer, and finds out the reasons for the change of oil well production. Channeling occurs in the injected water, and the injection pressure and water injection volume can not meet the requirements of reservoir displacement. Aiming at the problems existing in daily single well performance analysis, the system puts forward the best countermeasures to solve the technical difficulties of oil well production decline.

As shown in Fig. 4, the system can solve these problems of single well performance analysis: Whether the formation energy is effectively supplemented and fully utilized. Whether there are problems in the wellbore condition. The problems of water injection in water injection wells. Whether the production and absorption profiles are corresponding or not, and whether the interlayer production is balanced. Whether the oil well working system is reasonable or not. Whether there are problems in the working condition of downhole deep well pump.
Figure.5 Dynamic analysis module of injection production well group.

As shown in Fig. 5, the dynamic analysis module of injection production well group helps researchers master the oil-water movement law, injection production balance, oil layer production status and oil-water well production capacity in the range of well group through the comprehensive analysis of water injection wells and production wells in the well group, find out the contradiction and potential, and provide adjustment measures for improving the injection and production status of well groups.

The system can solve the following dynamic analysis problems of injection production well group: Whether the injection production conditions are normal and reasonable. Whether the water injection well works normally. Injection production balance and pressure field distribution. Whether the interlayer producing condition of well group is balanced or not. Whether the water line advances evenly on the plane. Whether the oil well has abnormal production.

As shown in Fig. 6, the reservoir performance analysis through production data and geological data, analyzes the production of produced wells, water injection wells, oil production of produced wells, water cut of produced wells, formation pressure, flowing pressure and other reasons, carries out comprehensive dynamic analysis, and puts forward improvement measures to ensure stable production of production wells and water injection wells.
The system can solve the following reservoir performance analysis problems: The adaptability of injection production well pattern. Production status of reserves. Whether the current water injection is reasonable. Whether the development effect becomes worse or not. Potential of oil and water well measures.
As an important part of this system, intelligent knowledge base system is composed of model base and management system based on dynamic analysis method. The model base system has the characteristics of storing all kinds of feasible algorithms in modularization and classifying them. Therefore, the foundation of establishing the whole model base is to determine the storage forms and representation methods of various algorithms. [4]

As shown in Fig. 7, there are many kinds of algorithms in the model base of reservoir intelligent dynamic analysis system. These algorithms can be divided into professional algorithm and decision algorithm. Because different users have different demands for the results of the algorithm, the algorithm is highly targeted, which reflects the limitations of a single algorithm model. Therefore, the system is required to provide a user interface for decision makers, which can realize the functions of unified algorithm extraction, classification and description. The above functions are the main functions of intelligent knowledge base management system. The general requirements for the functions of intelligent knowledge base system are as follows: The system is required to be able to carry out appropriate algorithm optimization to meet the needs of researchers. It is required that the update and maintenance services for the algorithm can be realized through the management system. It is required that the connection between the intelligent knowledge base system and other components can be realized through the management system.

4. Key technologies of free customization analysis method
The system adopts component development and decouples in the development process. [5] The control layer is responsible for the analysis and calculation functions, and the data related content is handed over to the underlying data layer. Easy to maintain and upgrade later. The key point is to develop the diagrams with unified functions in component mode so as to reuse them in other modules. For the expansion of requirements, only the control layer can be improved.

![Figure 8 Professional map components.](image)

![Figure 9 Basic table component.](image)

![Figure 10 Basic chart components.](image)
The classification of components is the core of system success or failure. As shown in Fig. 8 ~ Fig. 10, each component must have a complete function, which can provide complete function and analysis method when other modules are reused. If the component classification is too small, then the function is certainly insufficient, and the reuse of other modules will not play a great role in analyzing the analysis results. In terms of function, it is useless. If the component classification is too large, it will hinder the free customization analysis method. Components will not be able to solve complex and changeable scenes through free pages, and users will feel that the system is clumsy and inflexible in experience. The difficulty of component development mainly lies in the proficient degree of system development team to petroleum specialty and the separation classification of common functional requirements. The system development team has been engaged in reservoir dynamic development research for a long time, and has accumulated a lot of research experience. They are familiar with all aspects of reservoir production, and understand the data source and professional meaning generated in the production process. We use our own experience to classify and summarize the data volume that can form components, simulate a large number of use scenarios, and implement it in computer language in a "decoupling" way.

The system is driven by data sources, components, and computing modules. As shown in Fig. 11, these three parts are all functional units of dynamic analysis. From the perspective of module classification, the system extracts data management, report generation and method tools as the core of the system, and makes use of the flexible XMAL configuration function to combine and dynamically analyze pages of all modules on free pages, so as to realize complete custom interface content and analysis functions.

5. Conclusion
According to the dynamic analysis requirements and successful experience of China's oil fields, the system divides the data levels into organizational structure and geological unit, and different data levels correspond to different research needs and researchers. Reduce the time of searching data for different problems in dynamic analysis, reduce the working intensity of personnel in the operation area, and increase the efficiency of dynamic analysis. According to the dynamic analysis method, the analysis targets are divided into single well dynamic analysis, injection-production well group dynamic analysis and reservoir area dynamic analysis, and the analysis content of each level includes specific analysis methods. The system adopts the method of multi-page and multi-window combination, carefully studies and determines the function and data combination of each module to solve a certain problem in the reservoir production link, and uses this preset combination method to standardize the dynamic analysis conclusion. In the process of oilfield production, as time goes by, more and more complex and changeable problems will be faced. With the powerful analysis and custom function of the system,
targeted solutions can be quickly combined according to different problem scenarios to achieve cost reduction and efficiency increase for oilfield enterprises.

Acknowledgment
The study work is supported by the Basic Research on the Mechanical Activity Evaluation Method for Natural Fissure of Limnetic Shale around Wellbore (No. 51874239).

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