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Optimization of Production from the Reservoir to the Oil and Gas Treatment Point

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ABSTRACT: The article describes the management of digital technologies in oil and gas fields, to be able to cope with the increased volumes of data, conduct a quick assessment and improve management practices. It is shown that the new software providing sequence modeling covers all objects and processes in the field, ranging from productive formation and ending with the point of preparation of oil and gas, which helps to achieve the best economic results.

KEY WORDS: field, technologies, system, product, hydrocarbon systems, permeability, model, reservoir, sandstone, water flooding, pressure, dependence, rate, intensity.

I. INTRODUCTION

The oil and gas fields are undergoing a digital revolution. The management of their development has already undergone transformations in order to be able to cope with the increased volumes of data, conduct their quick assessment and improve management methods. The next step is being taken. The new software for modeling sequences of operations covers all objects and processes in the field, from the reservoir to the point of oil and gas preparation, which helps to achieve better economic results.

Oil and gas production, of course, is not easy and not cheap. Production costs are especially high for remote onshore and deepwater offshore fields. As rising costs are accompanied by lower demand, mining companies are looking for ways to squeeze every last drop from existing fields and optimize the development of new ones. The main factor in ensuring a breakthrough in efficiency along this path is the expansion of the use of intelligent digital technologies.

Digital technologies are becoming more complex and cover almost all types of activities in the fields. For example, the use of remote measurement systems or cartographic visualization of the main parameters has become everyday practice. These technologies arose in the 1980s, and over the past 15 years, their development has accelerated significantly. To date, several terms have been proposed to denote the intensive use of digital technology in oil and gas fields, of which the expression "intelligent field" is the most successful.

New to this application of digital technology by oil and gas companies is that the concept of an intelligent field combines various technologies to solve problems throughout the system.

This technology combines traditional tools, such as ECLIPSE reservoir simulation software, with other well-known models of production systems into a single end-to-end solution. This technology can be used both to increase production at existing fields, and in conceptual design to optimize the development of new fields.

This article discusses complex modeling of the development process, how it works and how it is used to solve oil and gas production problems.

Over the years, the accuracy and reliability of such programs has increased significantly. Now modeling complex formations has become easier; Now it is possible to simulate multiphase flows in pipes and optimize the operation of important equipment, such as compressors.

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Although modeling programs describe well the individual components of the fishing system, complications arise when trying to consistently apply these programs for analysis across the entire field. So, data exchange between individual components of a development system and departments of different profiles is often carried out in the form of spreadsheets that do not take into account the effects of the interaction of these components. A change in any of the components of the system entails a cascade of changes in the previous and subsequent components, and for the correct presentation of such an interaction, a significant modification of the stages of modeling may be required, which can be difficult, if not impossible at all.

II. METHODOLOGY

The application of traditional methods for designing field development is associated with two significant problems. The first of these is that all models following the formation model in the process chain are static. They describe the state at only one single point in time during the field's life, and to analyze the state at another point in time, these models must be reconfigured. The second problem is that traditional methods cannot take into account the dynamic nature of field development planning. For example, the flow rate of an existing well may change as a result of drilling new wells and violate the original plan. In addition, after events such as compressor replacement or the implementation of various secondary recovery programs, the exchange of raw data between the models is likely to lead to errors. These drawbacks of conventional field-wide analysis can lead to a host of complications, including unjustified drilling or installation of equipment with low or high parameters.

The solution to these modeling problems across the entire field is part of the intellectualization of the fields. The transition from sequential processes with fixed moments of time to dynamic processes in real time allows you to fully take into account the effects of direct and feedback. The main characteristic of an intelligent field is the possibility of wider use of interdisciplinary boundary conditions for coordinated modeling of adjacent objects of development and production systems globally throughout the field. The use of real-time dynamic data processing to model the impact of interrelated events, both in the past and in the future, set the stage for predicting field development indicators with the ability to adapt to changing operating conditions. This concept is the essence of integrated development modeling.

Comprehensive modeling of the development system is the result of the development of a well-known method - nodal analysis of the NODAL production system. This method is used to study complex interacting systems, such as piping networks, electrical circuits, and oil production systems. In this procedure, you must select a reference point (node) to divide the system. For such a node in the oil or gas production system one of several points can be taken - as a rule, the bottom hole or wellhead. The components that precede the assembly along the process chain are called the inflow section, and those following it are called the outflow section. For example, the perforation channels preceding the assembly at the wellhead are part of the inflow section, and the pipeline to the oil and gas treatment point is part of the outflow section.

Wherever a node is located, two boundary conditions must always be satisfied. The flow entering the node and the flow leaving it must be equal, and only one pressure can act on the node. For inlet and outlet flows, pressure and flow curves are constructed. The intersection point of these curves is a solution to the problem that satisfies both boundary conditions for flow and pressure.

Expanding the applicability of NODAL analysis from individual wells to more complex systems is not new. The first such proposal was made in 1971. It demonstrated how to connect reservoir models and ground infrastructure in order to get an agreed solution for a gas field collection system. Its implementation became the basis for subsequent proposals. A new distinguishing feature of the integrated approach was the introduction of commercial software that allows you to combine individual models of reservoirs, pipelines, training centers and economic indicators in order to develop the optimal solution. This is not a question of several modeling programs combined into a single complex, but of a computing platform that links together models of development objects and computer networks serving them.

This unifying approach to the modeling of the development process is reflected in the Avocet integrated modeling software package, which provides a coupled solution linking the reservoir (ECLIPSE reservoir simulation program), well and ground infrastructure (PIPESIM production system analysis program) with the oil and gas production site (simulation program HYSYS oil and gas processing) into a single field for managing field development. In addition to these commercial simulation programs, experts can create modules that describe specific processes in their area of expertise, or modules designed for internal company use, which can then be integrated into a global development model. The Avocet program supports implementation strategies that allow professionals who service different facilities to interact. A model environment on one computer can monitor and interact with the work of reservoir, pipeline, oil and gas, and economic applications installed on remote computers. The interface allows the user

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to graphically link individual models and view the results at each stage of the procedure for developing the optimal solution.

III. RESULTS

This approach provides a step-by-step iterative solution for predicting the characteristics of the field throughout the entire period of its development. As in the NODAL analysis, here at each time step in the node two iterative calculations are carried out taking into account the existing boundary conditions. One calculation determines the flow rates and pressures achievable in the reservoir, and the second determines the same parameters, but in the production system. Both calculations are repeated until the flow rates and pressures in the entire associated system are consistent. Then, the simulation program takes the next time step and repeats the procedure, working in this mode until the desired life of the field is reached.

At each time step, system restrictions apply to previous and subsequent sections in models and corresponding modeling programs. Although Avocet uses this general approach to develop solutions, the final combination of simulation programs will depend on the complexity and nature of the task.

The most difficult node for pairing is the bottom hole, and for most systems, pairing in the bottom will require the most lengthy calculations. As the mating point moves to the mouth and to other parts of the system, the duration of the calculations is usually reduced. When analyzing very complex fields, pairing at the bottom of the wells may be impractical or impossible, and it may be necessary to move the mating point to the surface.

Along with the location of the interface, the choice of restrictions on the composition of fluids also affects the duration and convergence of the calculations. For productive formations in which the influence of fluid composition on flow characteristics is not critical, a three-component finite-difference model ECLIPSE Blackoil can be used, suggesting that the formation contains a three-phase system consisting of oil, gas and water. If the injected fluids are mixed with reservoir hydrocarbons, a four-component reservoir simulation system may be considered.

For complex hydrocarbon systems, explicit compositional modeling is also applicable, which may be appropriate when an equation of state is required to describe the deep variation in the behavior of the reservoir fluid. Such a model may turn out to be the most suitable for systems containing condensates, light volatile or heavy oils, and also including displacement processes carried out by gas injection and other secondary production methods. It has sufficient flexibility to connect several reservoirs, for which different component models are created, with a terrestrial network. All of these features and other limitations will determine how well configured Avocet to solve the problem. After correctly configuring the model, it will indicate a clear path to end-to-end optimization of field development. The effects of direct and feedback between the structural elements of the model are taken into account when obtaining a convergent solution. An open architecture eliminates the problems associated with the use of various versions of software, and the ability to exchange data with remote computers allows for interdisciplinary interaction and optimal use of computing hardware. All these factors as a whole determine the effectiveness of solving oil and gas production problems. For example, one of the most cost-effective ways to increase the return on a developed field is to optimize production by comprehensive modeling of its development.

Although real-time data acquisition and transmission technology has been around for several years, its adoption by the oil industry is slow. Its role in the industry is growing with the realization of the importance of enhanced oil recovery. This is also facilitated by the simultaneous development of increasingly powerful and less expensive real-time systems. For example, BP called the intellectual field “the field of the future” and is working to make this concept a reality. BP combined integrated field modeling with a cartographic visualization system for parameters at its Red Oak West field in the Arkoma basin.

The operator of this field, located near Wilberton in southeast Oklahoma (USA), is BP North American Gas. About 800 gas production wells have been drilled on it, and the total length of pipelines covering an area 32 km (20 miles) long and 10 km wide (6 miles) is 400 km (250 miles). There are also seven compressor stations and over 70 mobile wellhead compressors. In the past, optimizing the development of such fields meant a very time-consuming study of large volumes of data on hundreds of wells obtained from many sources. As part of the Deposit of the Future initiative, BP has successfully brought Red Oak West to the forefront of implementing the concept of an intelligent field. The merger of the SCADA system with the Avocet Integrated Asset Modeler software package allowed for field development optimization and parameter map visualization.

The interactive integrated model of the Red Oak-West field can work both in an online tracking mode for monitoring ongoing operations and autonomously for evaluating alternative production strategies. In addition to interactive modeling, BP developed a data visualization tool for the Red Oak West field called MAPS, which gave engineers the opportunity to monitor the development performance of a large field. This made it possible to quickly identify wells operating below their potential and to identify production problems, such as accumulation of fluids or equipment failure.

IV. CONCLUSIONS

Although a key aspect of the program was to increase production, BP also found other benefits for it. System integrity control has been improved by using visual indicators and animations to inspect pipelines for corrosion, erosion, and flow rate. The company found that MAPS can be used not only to monitor the characteristics of wells and pipelines and their integrity parameters, but also to record the movements of personnel and equipment intended for field operations, such as maintenance, drilling or emergency evacuation.

Although there are many driving factors in the direction of field intellectualization, operators are likely to be mainly interested in lowering costs and increasing production. A significant increase in the value of projects will be their main impetus for adopting technologies that form the world of intellectual deposits. A key position in this world is integrated development modeling.

Integrated modeling of the development system is part of the paradigm of transition to digital technologies that change the appearance of oil and gas fields. Beginning 25 years ago in the form of a weak wave of transformations, this transition has gained strength and now, figuratively speaking, it is a real shaft. The core of comprehensive modeling of development and all related technologies that form an intellectual field is data integration and exchange. Consistent workflows are a thing of the past, and they are replaced by the components of a new concept, in which diverse information is effectively integrated and distributed across facilities in different regions of the world. These technologies remove barriers and expand interaction; they are aimed more at preventing negative events than at eliminating their manifestations. Comprehensive development modeling will occupy a key position in intelligent fields on the industry's path to real-time optimization opportunities.

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