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SMART OILFIELD. INTEGRATED APPROACH TO REAL-TIME ENTERPRISE MANAGEMENT BASED ON DIGITAL TOOLS USING MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE METHODS

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We introduce a new form of real-time oil production management using a set of integrated solutions (including integrated modeling, opportunity management (opportunities search and optimization), and integrated planning) implemented as part of the single Smart Oilfield concept. The approach includes modern-day digital tools and methods significantly different from traditional oilfield production and development practices. The implementation of the concept, built upon event prediction, assessment, and planning, brings positive results both at early and later stages of oilfield development, including for sites with hard-to-recover reserves and high-water encroachment.

Keywords: integrated modeling, integrated solution tools, integrated operations, integrated planning, mining maximization, restriction model, opportunity management, mining prediction, integrated operations center, machine learning, and artificial intelligence.

Intelligent Field and Integrated Solutions

Even though the Digital Field and Integrated Solutions are relatively new concepts, they have already become part of the everyday life of specialists and are discussed more and more within the framework of improving the efficiency of hydrocarbon production and field development management. Most companies implement the most advanced state-of-the-art technologies to improve production efficiency.

At the current stage of development, the integrated solutions technologies united by the concept of Intelligent Field, provide an increase in efficiency, primarily within the framework of operational management. The key ones are integrated modeling, capacity management and integrated planning. Modern technologies of integrated solutions, united under the Intelligent Field category, are actively developing nowadays and reviewed in works [1-10]. The use of the mentioned components as operational management tools forms the basis of the new integrated approach.

Let’s take an example to review the area of application for this approach and its key principles. Supposing it is necessary to increase oil production at the field of the 3-4 stages of development at full operation capacity of preliminary oil processing system and a high degree of water encroachment in the wells. A simple increase in fluid production can lead to a decrease in oil production (Fig. 1). In this case, it is necessary to select a mode of well operation in order to reduce offtakes from wells with high water cut, take into account interference of wells in reservoir conditions, and make adjustments to the operation of pipelines in the backpressure areas.

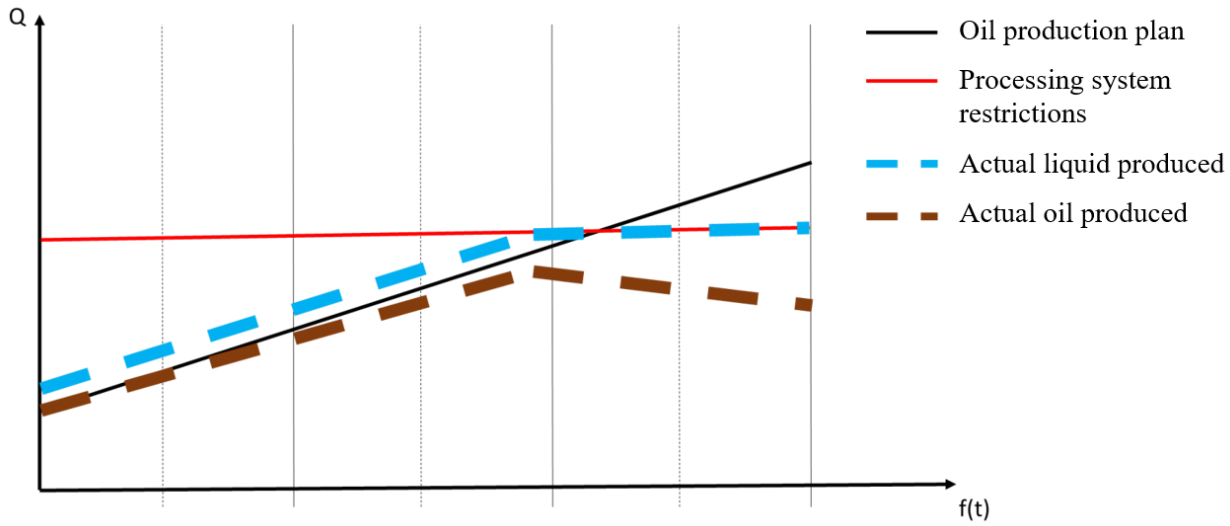

Fig.1. Decrease in production under conditions of limited preparation system

Development analysis alone is not enough to solve this complex issue. It is necessary to perform a full-fledged modeling of all production system areas, consisting of the following parts: reservoir, wells, gathering system, processing system, and pumping system. This is the first stage in production intellectualization. Based on the collected data, a concept of working with critical parameters is developed, the purpose of which is to increase production and reduce operating costs.

In order to ensure effective production management, taking into account the energy condition of the producing layer and optimal operating modes of wells and ground equipment, it is necessary to continuously monitor operating parameters of all technological facilities of the oil field, to ensure these parameters are transferred into the integrated modeling and control system, and to recalculate models and generate the necessary management activities in due time.

To increase the speed and quality of calculations, it is advisable to use machine learning and artificial intelligence methods. This will make it possible to achieve the convergence of planned, predicted and actual production indicators.

To achieve a significant increase in efficiency, it is necessary to switch to predictive management of field development based on the principles of optimal management, to revise the regulatory and methodological framework of development analysis and operational management of production.

The key principles of optimal management are the following:

- To ensure development of integrated management and optimal decision-making environment, in which the traditional local optimization problems give way to the formulation of an integrated optimization task, when the search for the best solutions is performed at the unified integrated model, and not within the framework of individual component models. It is obvious that the global optimum is preferable to the result determined for a group of local optimization tasks.
- To implement unified functional set of integrated tools and solutions for management processes: integrated modeling, integrated planning, potential-based management (using choke model), finding optimal solutions with the help of machine learning and artificial intelligence methods. Unified solutions and tools are the fundamental basis for integrated operations, and exclusion of any of the components will lead to significant losses in efficiency.

- To ensure setting and solution of optimal control tasks under the conditions of predictive development of processes, but not for the statistically fixed values of indicators according to historical data.

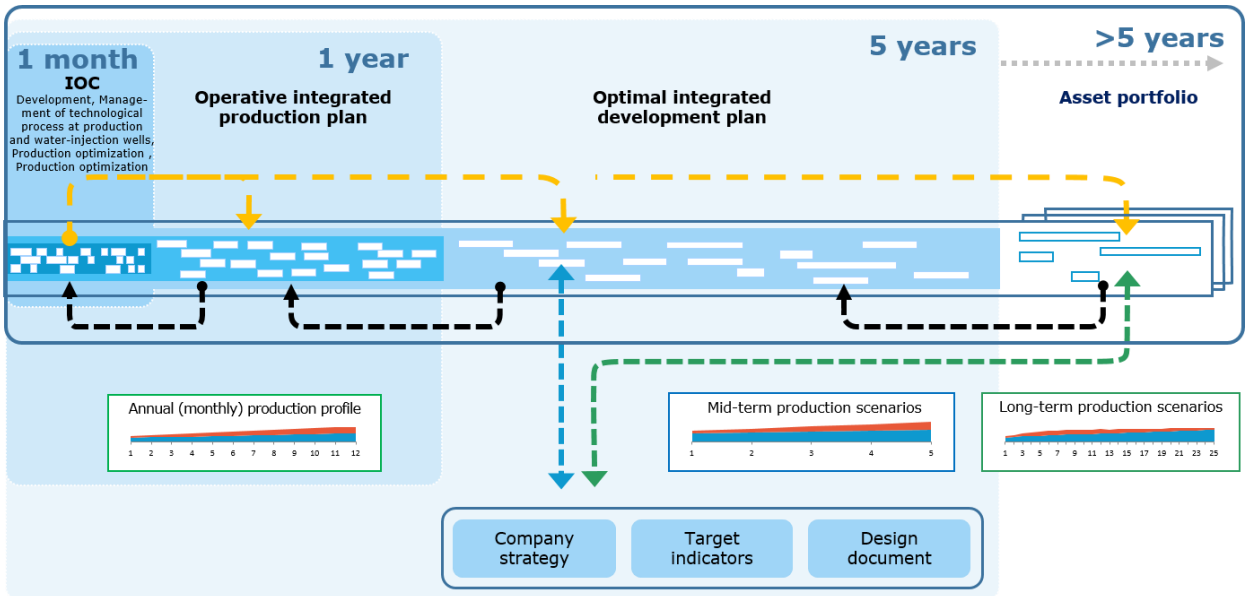

Fig. 2. Schematic view of optimal management

Integrated Operations

Transition to the new management methodology can be based on integrated operations – decisions jointly made by specialists of various departments: planner, technologist, geologist, economist, etc. Integrated operations are the elementary activities performed by integrated operations center (IOC) specialists. IOC's competence includes business processes for operational management of production using integrated solutions: integrated modeling, integrated planning and choke model management. All processes closely interact with each other, they are used in the operational, medium-term, and strategic timeframes of management (or planning) (Fig. 2). At the same time, any decisions made are synchronized within all management timeframes and considered in the integrated model.

Integrated Modeling

Modeling is an important part of production process at oil and gas production enterprises. Any field can be conditionally divided into components and for each component its own independent model can be created, which can be used to make the necessary calculations. It is possible to model a single object, or a part of ground infrastructure, or even all objects, and then to design, predict, or manage at this level.

The difficulty is that each model has its own set of tasks for a specific department of the enterprise. Geologists are responsible for the reservoir model, production department for the well model, and pipeline operation department for the gathering system model. Therefore, we face the task of establishing interaction between all infrastructure elements and departments, providing them with accurate and up-to-date information. The solution for this task is integrated modeling, which ensures the following activities:

- Automatic collection and uploading of actual production data, research and activities performed at technological facilities.
- Data exchange between the company's departments in real time.

- Updating of the integrated model in accordance with actual production data and changes in infrastructure and equipment.
- Selection of the most effective measures for development management within operational and medium-term timeframes.
- Calculation of technological modes for wells and surface equipment operation.

Integrated modeling also allows defining control levers to flexibly influence production parameters to achieve the target result. The calculation core, used to calculate all planned activities must ensure interaction of the model with the IT systems of the company, analyze calculations, and generate reports understandable not only by professional discipline engineers, but also for the company's management.

We propose to use the Russian digital platform AVIST and AVIST Oil & Gas module as tools for working with integrated models, selecting scenarios, and ensuring group work. One of the main methods of development regulation is manipulation of operating modes at production and injection wells, pipelines of the reservoir gathering and pressure maintenance system, and oil and gas processing systems. This method is used as basis for production forecasts in hydrodynamic models, and the main criterion for assessing the model quality is an adequate response of production system to a specific modeled impact.

Integrated Planning

Within the Intelligent Field concept, integrated planning is seen as part of the business model and is linked to predictive analysis in terms of accounting. This approach allows to efficiently plan events, schedule them, and flexibly influence changes at all planning timeframes. This allows minimizing conflicts in the activities of various departments.

The economic effect of integrated planning consists of the following features:

- Increased production due to optimization (combination) of operational and investment measures based on the integrated model.
- Reduction of shortages (forecasted losses).
- Increase of efficiency of interaction between departments, optimization of labor expenses.
- We proposed to use the Russian digital platform AVIST and AVIST.Planning module to automate the integrated planning process. All process participants work with the solutions - including process owners, planners working with integrated and production plans, and ordinary users taking part in events. The solution can be used to perform automatic optimization of schedule for any specific task: production maximization for the planned period, shortages minimization by up to 3% by indicator, reducing starts and stops by 20% by indicator, etc.

Management of Potentials (Choke Modeling)

Changes in production facilities potentials and the system in general are estimated and predicted as part of the choke model management, to ensure the planned production indicators are reached:

- On a monthly basis – to optimize technological modes of equipment operation.
- On an annual basis – to prioritize implementation and modeling of workover actions and administrative and technical measures.
- Within mid-term and long-term timeframes – for investment planning of infrastructure reconstruction and commissioning of new facilities.

The Russian AVIST digital platform and AVIST Oil & Gas module can be used as a tool to search for technological and production potentials, and to choose optimized solutions.

The Unified Concept of Intelligent Field

At this stage of technologies' and procedures' development, the implementation of the unified Intelligent Field concept involves the development of a target model of business processes, consolidation of all production and regulatory information, and creation of an integrated information system ensuring the following:

- Automatic data exchange between the IOC processes.
- Collection and analysis of geological and geophysical data, planned and actual production data from field and accounting systems.
- Automatic processing of newly received data, its inclusion into analytics and forecasts.
- Reporting for a given period.

This set of functions can only be implemented with the help of appropriate digital tools. In particular, the Russian digital platform AVIST proposed for use within the framework of the concept, ensures interconnected operation of the integrated modeling modules, integrated planning, and management of potentials. Consolidation of production data ensures interconnection and accounting of all significant factors at the facilities. This is important, since attempts to increase production of a given well without considering the influence of other wells might lead to a decrease in production at interfering wells.
The tools and mathematical parameters of AVIST platform are focused on improving process efficiency and maximizing hydrocarbon production while optimizing the cost of reservoir pressure maintenance while preserving reservoir potential as carefully as possible.

The use of integrated production management information system and potential management methodology with the help of integrated modeling makes it possible to qualitatively predict the probability of interference and crossflows in the reservoir, to identify and take into account production processes' interference and to establish optimal interaction.
The decision-making process in production management consists of the following main stages of analysis and calculations:

- Automatic receipt of geological and geophysical data, planned and actual production data from production and accounting systems.
- Timely update of integrated models with actual production data.
- Calculation of potentials for production facilities.
- Operational optimization of technological modes of production and injection wells.
- Prioritization of geological and technological activities within the operational timeframe.
- Planning investment activities within the mid-term and strategic timeframes, to ensure required production levels and oil recovery factor.
- Modeling and evaluating efficiency of investment activities in integrated modeling systems with long-term management timeframes.
- Operational optimization of the integrated plan.
- Monitoring of integrated plan execution (plan/actual) and operational production management.

If we group the activities of the listed stages by management timeframes, the decision-making process will look like this:

- On a monthly basis, the models are only updated with actual data, automatic optimization of activities takes place and technological modes are calculated.
- Activities for a 90-day timeframe are prioritized.
- On an annual basis, calculations of potentials, operational modeling, and economic assessment are performed.

The described integrated approach to production management is efficient both at the early and late stages of field development even for marginally profitable and wells with high water cut. To achieve the highest efficiency of production and development processes, the most important conditions are constant coordination of joint actions of various specialists, adherence to the principles of optimal management in planning and forecasting of constraints, timely assessment and optimization of activities and technological modes of well operation with the help of integrated models.

Therefore, we propose the new approach based on the principles of optimal management in the subject area of development analysis and operational production management. The use of these principles to solve applied tasks allows achieving maximum efficiency.

References

1. T. Rosendahl, V. Hepsø, Integrated Operations in the Oil and Gas Industry: Sustainability and Capability Development, Business Science Reference (an imprint of IGI Global), 2013.
2. L. L. Tikhomirov, Integrated Operations: From Idea to Implementation, Uzbekistan Oil & Gas Journal, 2016, No.5.
3. M. Al-Balushi et al., Real-Time Surveillance: How System Integration Allows One Company to Minimize Deferment, Optimize Production, Maximize Test Unit Capacity, and Track the Operating Envelopes of its Wells, SPE-167857-MS, 2014.
4. W. Palen, A. Goodwin, Increasing Production in a Mature Basin: “The Choke Model”, SPE-36848, 1996.
5. O. A. Talabi et al., Integrated Asset Modeling: Modernizing the Perspective for Short-Term Forecasting and Production Enhancements, SPE-182496-MS, 2016.
6. J. P. M. van Vliet and P. T. Male, Well, Reservoir and Facility Management – Process, Practice and Impact, SPE-185880-MS, 2017
7. Huiqiang Shen et all, Design of an Integrated Production Planning System Framework Based on Simulation Using a Production Information Model, Proceedings of the Twenty-seventh (2017) International Ocean and Polar Engineering Conference, San Francisco, CA, USA, June 25-30, 2017.
8. S. Volkov et al., Optimization of Oil and Gas Production Based on Integrated Planning, SPE-181955-MS, 2016.
9. A. Nagimzianova, M. Gurieva, Innovative Oil and Gas Extraction Optimization Methods Based on Integrated Planning, Theory.Practice.Innovation, September 2017.
10. K. Tagirova, Improving Oil Extraction Efficiency Using Process and Volume Management Coordination // Ufa State Aviation Technical University Herald, No. 2. Ufa: USATU, 2008.- P.48-52.
11. GOST R 55414-2013. Specifications for technical project of field development. – 2013.
12. RD 153-39.0-110-01. Methodology guidance on field and geology analysis in oil and gas field development. – 2002.

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