II STRATEGIC CONGRESS 2017

INTEGRATED MANAGEMENT OF OIL AND GAS CONDENSATE FIELDS’ DEVELOPMENT: BEST PRACTICES
The Company’s production structure requires special attention to be given to basic production.

- Current petroleum production: 88% basic, 12% stimulated.
- Potential for initial reservoir pressure (Pres): +34%.
- Potential for target bottom-hole pressure (WBHP): +6%.
- Potential petroleum production: 140%.

The development management potential is significant and requires an integrated approach.
Six-component system to be managed

\[ Q_n = \sum_{i=1}^{12} K_{\text{экс}} \cdot \text{СДФ} \cdot K_{\text{прод}} \cdot (P_{\text{пл}} - P_{\text{заб}}) \cdot (1 - \text{обв}) \]

- An integrated approach is needed for planning, monitoring and control of each of the six components
- Each component is eligible for potential-based planning
Target model for production management

**Basic production management**

**WELL STOCK**
- Reviewing of well stock in operation cost efficiency
- System of working with inactive production well stock
- Well stock planning

**Equipment**
- $P_{\text{bottom-hole}}$
- $K_{\text{ex}}$
- A system of selecting an optimum bottom-hole pressure in producing wells
- Analysis and planning of $K_{\text{ex}}$

**Reservoir potential**
- $P_{\text{reservoir}}$
- Prod Index
- Automated monitoring of current development status
- Factor analysis of basic production deviation
- Parameter planning

**Processes and activities**
- Activation of inactive well stock
- Shut down of some of the well stock
- Well down time reduction
- Reservoir pressure maintenance system optimization (incl. re-engineering, remedial cementing)
- Restoration of the productivity indexes including acidizing

**Goals:**
- Make wells, underground equipment and surface infrastructure operate more efficiently
- Reduce per-unit costs
- Realize end-to-end rating of actions to reach the potential
Closed self-consistent parameters calculation

**Material balance equation solving**
Self-coordinated indicators of production/injection and reservoir pressure

- **Reservoir pressure forecast**

- **Closed self-consistent parameters calculation**

\[
Q_{\text{зак}} = K_{\text{прием}} (P_{\text{заб}} - P_{\text{пл}})
\]

- **Well stock changes**
Production wells are shutting down due to low cost efficiency / high water cut
Conversion to injectors (selected, or specified number)

- **Associated gas production calculation**
Using PVT model at the designed reservoir pressure

\[
Q_{\text{ПНГ}} = q_{\text{неф}} R_s (P_{\text{пл}}; \text{ОИЗ})
\]

- **Forecast of fluid production and injection**
Calculation of production rates of fluid /injection based on productivity factors
bottom-hole pressure is assumed to be constant

\[
W_\text{акв} = f(\text{ОИЗ})
\]

\[
W_\text{пл} = -Q_{\text{жкл}, \text{усл.}} + W_\text{зак} + W_\text{акв}
\]

\[
P_{\text{пл}} = K_{\text{прод}} \frac{W_\text{пл}}{C_{\text{эф}}}
\]

- **Oil production calculation**
Using displacement efficiency, production rate of fluid and current recoverable reserves

\[
q_{\text{неф}} = q_{\text{ждк}} (1 - W_\text{СВ})
\]

\[
W_\text{СВ} = f(\text{ОИЗ})
\]
Verification and data QC during initial data loading

During data loading into OIS system it is necessary to specify the reason of change if the loaded value is out of given range.
Digitalization.
Data science for verification of geology and well performance data

**Project goal:** automatization of uploading, verification and analysis of large data arrays using machine learning algorithms to make production decisions quicker and more efficient

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**Data for analysis**
- Production history
- Telemetry
- Porosity and permeability properties of the reservoir
- Logging
- Field research
- Geological maps

**Main (expected) effects**
- Labor to be reduced by more than 20 man-years
- Deterministic models to become of a higher quality

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**Data filtering**

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**Technology partners**

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**Package processing for simulators**
Reserves verification example

Stage 1:
• STOIIP verification, estimation of the sweep efficiency
• Risk maps construction
• Preparation and realization of the activities in order to prove localized remaining recoverable reserves

Stage 2:
• Vertical and areal hydroscanning using reference well grid
• Integration of collected data into the reservoir model and precise localization of remaining recoverable reserves
• Planning and implementation of well stimulation program

Vertical hydro-scanning
HPT-SNL + TSNL

Areal hydro-scanning
ИКГ + МДКВ

Integrating the data into RM

Analysis and planning of well stimulation program

Precise localization of remaining reserves
Digitalization.
The search for missed reservoir intervals

**Project goal:** missed reservoir intervals localization in the cross-section by using modern machine learning algorithms to analyze results of geological and geophysical studies and field production data

**Main (expected) effects**
- Increase of reserves in the assets of production
- Up to 1 million tons of extra production by 2025

**Technology partners**

Reservoir prediction

Analysis of well logging data and search for productive intervals
Models hierarchy for automated development control

- Shakhmatka-Tekhrezhim / Mekhfond information systems
- Factor analysis
- AvtoControl Razrabotki information system
- Block-factor analysis
- Sector 3D hydrodynamic models
- Proxy-model
- 3D simulation model
- Benchmarking tools
Waterflooding management modeling example

Results
- Oil production increment: 1,800 t
- Water injection volumes reduction: 255,000 m³
Reservoir management tools development
Creation of optimization algorithms

New assets
Selection of the optimal development system

Mature assets
Waterflooding management

Reservoir model or integrated model + auto-adaptation tools

+10 % NPV
+1 % RF
Effect from implementation in new assets

GPN Optimization Framework

Economic model

In the future: reservoir models based on machine learning

+1 %
Production increment for current assets within 3-5 years future
Digitalization. Metamodelling of the well inflow in the development element

**Project goal:** Optimization of the development system with the help of reservoir inflows modeling in the development element using machine learning methods, numeric modeling for operational control tasks and reservoir management.

**Main (expected) effects**
- Reduction of errors in identifying reservoir problems by 2%
- Making hydrodynamic calculation faster 10 times and more

**Data for analysis**
- PVT-properties
- Relative permeability
- Capillary pressure curves
- Porosity and permeability distribution
- Initial distribution of pressure, water, oil and gas saturations

**Surrogate model**

- Data filtering
- Target function
- Machine learning

**Optimization of the development system**

**Technology partners**

**Synonyms:** surrogate model, proxy model, hybrid model
Introduction of the Automated Selection of Well Interventions information system

Algorithms for calculation and selection of candidates for hydraulic fracturing

Business effect

Number of Side-Tracks

- 2015 +56% to 2014
- 2016 +11% to 2015

Oil Production from Side-Tracks, th. t

- 2015 +52% to 2014
- 2016 +22% to 2015

Result of implementation the Well Stimulation Selection tool:
- Estimation of the well potential and increasing of well stimulations operations
- Stimulation candidates rating: selection of the best candidates for the well stimulation program
The example of multi-stage hydrofracturing horizontal well design optimization

Optimal design for the low permeable reservoirs
3mD – 150 m/frac, 1mD – 100 m/frac
Machine learning in interpretation of the study results

**Project goal:** decreasing of well downtime and increasing of geotechnical operations efficiency due to automatization of well data analysis based on self-learning algorithm and fewer number of active experiments

**Main (expected) effects**
- Savings of RUB 200 mln. per year
- Increasing of well test coverage from 20-30% to 100%

**Technology partners**

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Well stock -> Production data -> Self-learning algorithm

- Action plan
- Well stimulations recommendation
- Expert review
Increasing of the profitability from artificial lift well stock

Calculation of the key profitability model parameters is automated:

- The forecast of oil production, water cut and rates of depletion is dependent on bottom-hole pressure
- Electric power consumption
- Anticipated average time before failure
- ESP selection
- OPEX, REVEX, CF, NPV

Well Profitability Assessment for Various Production Modes

Economically Optimal Bottom-Hole Pressure vs Water Cut

Optimal WBHP = 85 atm
Example of reengineering of the surface facilities system

- Conversion to injectors
- Increasing of THP
- Decreasing of THP
- Optimization of WBHP
- Withdrawal from the inactive fund

Optimization of WBHP

Estimated effect: 570 th.t / 10 years

Diameter proportional to oil produced over the last month
Conclusions

1. A sufficient set of tools has been accumulated for the integrated management of the production from mature fields

2. The hierarchy of approaches allows to maintain a balance between the detail of models and the speed of decision-making

3. The existing potential for the production from mature fields is concentrated in the continuation of the integration of the value chain tools

4. A breakthrough in the development of methods and algorithms for integrated development management is concentrated in the areas of usage of machine learning methods and big data science

5. The trend towards digitalization makes new demands on the role of the engineer: from performing usual operations to the system integrator-analyst