Kolbeko A.B., postgraduate student,

Tyumen State University, Tyumen, Tyumen.

E-mail: stud0000108724@study.utmn.ru

**Development Of A Methodology For Modeling The Processes Of Hydrate Precipitationin The Bottomhole Zone Of Wells And Assessing The Impact On Productivity:**

The article deals with the main tendencies of oil and gas industry development, development of methodology for modeling hydrate formation processes and assessing the impact on well productivity by expanding the software used in the industry.

Keywords: Modeling, heat and mass transfer, hydrate formation, programming, extension development, tNavigator.

Historically, the development of oil and gas production began with the development of the most accessible fields. In Western Siberia, these were Cenomanian deposits with favorable characteristics, where complex modeling of production processes was not required.

Currently, there is a trend towards the development of more complex fields both in Russia and abroad. Hard-to-recover reserves are being actively developed in Western Siberia (Bazhenovskaya and Achimovskaya formations), and in Eastern Siberia - fields with problematic geological conditions (Bukskoye and Kurosovskoye formations). This trend is typical of the global oil and gas industry as a whole, where simple fields are gradually coming to the end of their development cycle, and more complex fields have to be brought into development in their place.

For example, the Elgin field in Great Britain (Sea North) is characterized by difficult production conditions due to high pressure and temperature [1]. In Australia, the development of hydrocarbon fields in the Cairns Basin also encounters problems with fracturing, peculiarities of accumulation and accumulation of hydrocarbons in the rock [2, 3].

There are common technical challenges in the development of such fields:

1. Increase of well drilling time

2. Development of deposits in non-typical conditions, the need to take into account phase transitions

3. The need to apply new methods of stimulation of the reservoir to intensify production

4. Effective choice of stimulation methods is determined by the use of effective methods of modeling physical processes occurring in the reservoir 4.

The solution of these problems requires the use of modern methods of numerical modeling of heat and mass transfer processes, which is becoming a prerequisite for the effective development of both Russian and foreign fields at late stages of production.

Modern commercial hydrodynamic simulators allow modeling systems with dual porosity and permeability (Dual Porosity - Dual Permeability, DP-DK), provide models of Black Oil fluids for fields for which it is not necessary to consider phase transitions, composite models for deposits with the possibility of retrograde condensation of gas, indication of hydrate formation, methods of thermal influence on reservoirs [4, p. 251]. The developed models and methods are sufficient for solving problems in the oil and gas industry for modeling complex reservoirs with high natural fracturing, shale formations and carbonate reservoirs, the solvers allow to take into account the interaction between the matrix (porous medium) and fractures (highly permeable channels).

A comparison of the listed functionality, supported models and methods among the most popular modern solvers is presented in Table 1.

|  |  |
| --- | --- |
| **Simulator** | **Models and methods** |
| ECLIPSE | There is support for dual porosity and dual permeability models, modeling of matrix-fracture interaction through fluid exchange parameters, SAGD, VAPEX, BUTEX, CSS, ISC thermal methods. |
| CMG | There is support for dual porosity and permeability models, ability to model fractured reservoirs, including natural and induced fracturing, SAGD, VAPEX, BUTEX, CSS, ISC thermal methods. |
| tNavigator | There is a high-performance solver for large field models, full support for DP-DK models, the ability to work with fractures of different nature (natural, hydraulic fracturing), thermal methods of action SAGD, VAPEX, BUTEX, CSS, ISC, indication of hydrate formation. |

Table 1. Comparison of functional capabilities

It can be seen that the documentation of only one of the considered simulators states the presence of functionality to identify hydrate precipitation, and the rest of the functionality is mostly interchangeable. It is most likely that the need for such functionality has arisen due to the emergence of tasks on the part of oil and gas companies in the CIS in modeling deposits with abnormal temperatures and pressures, in the process of which may reach conditions of hydrate formation, which has a negative impact on the dynamics of development. The task of cost-effective development of anomalous reservoirs and prevention of hydrate formation in the reservoir is considered in modern publications of Russian authors [5], but has not yet been presented in foreign literature.

However, referring to the implementation documentation from tNavigator one can find that the simulator uses the Langmuir hydrate formation model, with hydrates having no effect on fluid flow and not being included in the calculation. This parameter is a reporting parameter and primarily shows whether their formation is possible or not [4, pp. 451-456].

The effect of particle precipitation could be tried to account for, for example, using some adaptation of Leonov's model of simultaneous colmatation and particle suffusion, applying it to the settling of hydrate particles in the rock skeleton. In this way we can try to dynamically determine the free porosity and permeability of the reservoir for the displaced fluid. Mathematical formulation and assessment of applicability of Leontief model for the problem of estimation of pore space parameters change in the rock skeleton by solid suspension particles was considered in the article [6].

Thus, we can conclude that the development of a method based on the Langmuir model implemented in tNavigator, together with the Leontief model of simultaneous colmatization and particle suffusion considered in [6] is a promising area of development and can be implemented as an extension for tNavigator, relying on the API provided by the developers for integration with the software system. Such an extension can provide a solution for some of the current problems of the modern oil and gas industry in Russia, listed earlier.

**Список литературы**

1. Maslin Elaine High-pressure high-temperature developments in the UK Central North Sea / Maslin Elaine – текст: электронный // научно-практический журнал: OE Offshore Engineer. The Future of Offshore Energy & Technology. – 2014 – URL: https://www.oedigital.com/news/455434-the-hpht-challenge (дата обращения: 16.04.2025)
2. Adam H. E. Bailey, Lidena K. Carr, Russell Korsch. Australia’s Onshore Basin Inventories – foundational knowledge synthesis for better design of precompetitive data acquisition / Journal article on the Cairns Basin petroleum systems / The APPEAJournal – 2023 - Vol 63 – P. 209-214. – DOI: 10.1071/AJ22045. - URL: https://www.publish.csiro.au/aj/fulltext/AJ22045- Текст: электронный (дата обращения: 16.04.2025)
3. Slatt R.M., O'Brien N.R. Pore types in the Barnett and Woodford gas shales: Contribution to understanding gas storage and migration pathways in fine-grained rocks / AAPG Bulletin. - 2011. - Vol. 95, No. 12. - P. 2017–2030. - DOI: 10.1306/03301110159.
4. Техническое Руководство tNavigator 24.2: Rock Flow Dynamics. - Москва, 2024. – с. 4389 – URL: https://irmodel.ru/news/vyshel-novyj-reliz-tnavigator-24-2 (дата обращения: 16.04.2025).
5. Тройникова, А. А. Совершенствование методов предупреждения гидратообразования на газовых и газоконденсатных месторождениях: / Тройникова, А. А. / Научно-исследовательский институт природных газов и газовых технологий – Газпром ВНИИГАЗ. - Москва, 2022. - 142 c.
6. Самсонов К. Ю. Методика определения технических параметров ограничения водопритока / К. Ю. Самсонов, А. П. Шевелев // Вестник Тюменского государственного университета. Физико-математическое моделирование. Нефть, газ, энергетика. - 2016. - Т. 2. № 2. - стр. 121–130.