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Modelling the Development of the Achimov Natural Gas Deposits

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Abstract. Currently, the Russian Federation is one of the largest natural gas producers in the world, second only to the United States in production. The world's largest proven gas reserves are located in Russia. Despite the colossal initial volumes of gas, many unique Russian fields have been operating in a declining production mode for a long time (for many years) and are steadily approaching the transition to the mode of fields with low-pressure gas, which is currently economically unprofitable to compress for supply to main gas pipelines for transportation to consumers. New gas and oil and gas condensate fields of the Russian Federation are located in new undeveloped regions of Russia. These areas are distinguished by a harsh climate, lack of transport infrastructure, are located far from existing gas pipelines and are characterized, as a rule, by a complex geological structure and multicomponent gas composition, which inevitably entails a further increase in the already considerable capital and operating costs, time lag, which, accordingly, reduces economic attractiveness of their development for gas producers. In this regard, additional exploration and production of gas from the Achimov deposit - formations lying below the developed Valanginian deposits of large gas fields, close to the transition to closure, is of great interest. The production of gas from the Achimov deposit at fields with a built infrastructure, where there is a connection to the main gas pipelines, can significantly reduce costs - both production and capital. The article is devoted to the issues of modelling gas production of the Achimov deposit.

1. Introduction

At present, the Russian Federation is one of the largest producers of natural gas in the world (natural and associated), second only to the United States in production [1]. The world's largest proven gas reserves are located in Russia [2]. Despite the colossal initial gas volumes, many unique Russian fields have been operating in a declining production mode for quite a long time and are steadily approaching the transition to the mode of fields with low-pressure gas, which is currently economically unprofitable to be compressed to be fed into gas pipelines for further transportation to consumers. To increase production volumes and even to simply preserve existing ones, it is necessary to compensate for the falling volumes of produced gas and, accordingly, it is necessary to commission new fields. New oil and gas condensate and gas fields of the Russian Federation are located in new undeveloped regions of Russia with a harsh climate. These areas are characterized by the absence of transport infrastructure, are located far from the existing main gas pipelines and are characterized, as a rule, by a complex geological structure and a multicomponent composition of the gas contained in them, which inevitably entails a further increase in capital and operating costs, time lags and, accordingly, reduces the economic attractiveness of development. for gas producers. In this regard, additional exploration of layers lying below the developed Valanginian deposits, large gas fields, close to the transition to the category of low-pressure ones, is of great interest. These formations include deposits of the Achimov deposit.

2. Features of the structure and development of the Achimov deposits

Gas production of the Achimov deposit is carried out at the field with already built infrastructure, where there is a connection to the main gas pipelines, and this allows to sufficiently reduce costs - both operational and capital, reduce the time lag and shorten the commissioning time. Production from these deposits can significantly facilitate the production of gas from the Cenomanian and Valanginian deposits in the final period of their development using a unit with a highly efficient ejector. Thanks to the use of this unit, gas from the Achimov deposit, due to its high reservoir pressure, will be able to lift gas and condensate from the overlying reservoirs and exclude the use of booster compressor stations [3]. In the absence of sufficient demand for gas, it is possible to switch to re-injection of the produced and dried gas back into the reservoir to intensify the production of liquid hydrocarbons (oil or condensate), depending on the type of a specific Achimov deposit. All this, in turn, will allow, to a certain extent, to reduce the carbon footprint from gas production from the Achimov deposit and allow counting on a reduction in the cross-border carbon tax, both on the gas itself and the exported products in the production of which it was used [4].

The strata of the Achimov deposit are located below the strata of the Valanginian horizons at depths from 3500 to 4000 m. Deposits of the Achimov deposit can be gas, gas condensate and oil and gas [5]. A common feature of the Achimov deposit is a difficult-to-permeable reservoir, which makes the development quite difficult compared to the Cenomanian and Valanginian deposits. The drilled vertical production wells similar to the wells in the Cenomanian and Valanginian formations in the Achimov deposit have an extremely low production rate and do not even justify the cost of drilling. Commercial development of the Achimov deposit is carried out by drilling horizontal wells followed by hydraulic fracturing. The fracturing capacity must be sufficient to crush the reservoir of the productive formation and release gas and liquid hydrocarbons for recovery to the surface. At the same time, hydraulic fracturing should not damage the interstitial layers and not cause the flow of produced hydrocarbons from the productive formation to other deposits. Optimization of the development process of such a formation consists in optimizing the frequency of the vertical wellbore grid, the length of the horizontal sections, the number of horizontal sections (bottom holes) extending from one vertical wellbore and the number of hydraulic fractures in one horizontal section.

3. Modelling the development of the Achimov deposit

Each *i*-th development project of the Achimov deposit A_{ci} as an object of modeling can be represented by five vectors Each *i*-th development project of the Achimov deposit A_{ci} as an object of modeling can be represented by the following composition of vectors

$$A_{ci} = (d_{gi}, d_{hi,} c_{ig}, c_{ih}, k_{ig,} k_{ih,} z_{ig}, z_{ih}) \ \ i \in I_l, \tag{1}$$

- where d_{gi} is a vector of dimension T characterizing the volume of gas production from the *i*-th Achimov deposit for the last year of the period $t=1,\ldots,T$.
- d_{hi} - is a vector of dimension T characterizing the volume of condensate production from the *i*-th Achimov deposit for the last year of the period $t=1,\ldots,T$.
- c_{ig} - a vector of dimension T characterizing the volume of operating costs for natural gas production from the *i*-th Achimov deposit for the last year of the period $t = 1,\ldots, T$.

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- c_{ih} - a vector of dimension *T* characterizing the volume of operating costs for the production of liquid hydrocarbons from the *i*-th Achimov deposit for the last year of the period $t = 1,\dots, T$.
- k_{ig} - a vector of dimension *T* characterizing the volume of investments in natural gas production from the *i*-th Achimov deposit for the last year of the period $t = 1,\dots, T$.
- k_{ih} - a vector of dimension *T* characterizing the volume of investments in the production of liquid hydrocarbons from the *i*-th Achimov deposit for the last year of the period $t = 1,\dots, T$.
- z_{ig} - a vector of dimension *T* characterizing the volume of the carbon footprint accompanying the production of natural gas from the *i*-th Achimov deposit for the last year of the period $t = 1,\dots, T$.
- z_{ih} - vector of dimension *T* characterizing the volume of carbon footprint accompanying the production of liquid hydrocarbons from the *i*-th Achimov deposit for the last year of the period $t = 1, ..., T$

To simulate operating costs in the development of the Achimov deposit of the field:

- $c_{gi}(t)$ - unit costs for gas production at the *i*-th Achimov deposit of the field for the period *t*.
- $c_{hi}(t)$ - unit costs for the production of liquid hydrocarbons at the *i*-th Achimov deposit for the period *t*.

The total operating costs $C_i(t)$ for the production of hydrocarbons at the *i*-th Achimov deposit of the field for the period *t* will be:

$$C_i(t) = \sum_i c_{gi}(t) * d_{gi}(t) + \sum_i c_{hi}(t) * d_{hi}(t) \quad (2)$$

To model capital investments in the development of the Achimov deposit of the field, the following are introduced into consideration:

- $k_{gi}(t)$ - specific capital investments in gas production at the *i*-th Achimov deposit of the field for period *t*.
- $k_{hi}(t)$ - specific capital investments in condensate production at the *i*-th Achimov deposit of the field for the period *t*.

The total capital investments $K_i(t)$ in the production of hydrocarbons at the *i*-th Achimov deposit of the field for the period *t* will be:

$$K_i(t) = \sum_i k_{gi}(t) * d_{gi}(t) + \sum_i k_{hi}(t) * d_{hi}(t) \quad (3)$$

To simulate the size of the carbon footprint in the development of the Achimov deposit:

- $z_{gi}(t)$ - the specific volume of the carbon footprint accompanying gas production at the *i*-th Achimov deposit of the field for the period *t*.
- $z_{hi}(t)$ - the specific volume of the carbon footprint accompanying the production of condensate at the *i*-th Achimov deposit of the field for the period *t*.

The total carbon footprint $Z_i(t)$ accompanying the production of hydrocarbons at the *i*-th Achimov deposit for the period *t* will be:

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$$Z_i(t) = \sum_i z_{gi}(t) * d_{gi}(t) + \sum_i z_{hi}(t) * d_{hi}(t) \quad (4)$$

The choice of the most attractive project for the development of the Achimov deposit is carried out using optimization modelling, in which each project acts as an independent field, which makes it possible to choose the most economically attractive one with the shortest commissioning time. Since the a_{ci} Achimov deposit can be brought into development by only one project out of *S* possible, differing from each other in the number of wells, bottom holes in each vertical wellbore and the number of hydraulic fractures and, accordingly, the level of gas and liquid hydrocarbon production, investment volumes and operating costs, then for it, as an object of modelling, a ban should be placed on the implementation of a part of different projects, both in parts and the input of more than one project. For this, an obligatory logical condition is set in operation; only one of s possible projects can be put into operation during the entire simulation period *t = 1, ..., T*:

$$\sum_{\tau=1}^{S} a_{ci}(\tau) \le 1 \quad (5)$$

From the set of *S* development projects of the *i*-th Achimov deposit, using optimization modelling, the project is selected that is most optimal in terms of economic characteristics and commissioning time/

4. Conclusion

Exploration and development of unaffected formations of active fields belonging to the category of mature and long operating in the mode of declining production will significantly extend the period of production of marketable hydrocarbons. The development of the Achimov deposit is currently making it possible to significantly accelerate the commissioning of new production capacities, significantly reduce production costs and capital investments, and significantly reduce the carbon footprint from hydrocarbon production.

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