ABSTRACT

dissertation submitted for the degree of Doctor of Philosophy (PhD)
(PhD) degree in EP 8D07202 - "Petroleum Engineering" by
Zaurbekov Kadyrzhan Seitzhanovich

Research and improvement of technology and techniques of Steam-assisted gravity drainage on oil reservoirs

Introduction. In order to maintain hydrocarbon production rates, the world began not only to develop new fields, but also to develop so-called off-balance reserves that could not be developed before. A significant share of such fields are reservoirs with high-viscosity oil. According to estimates given in the literature, the world total volume of heavy oils is estimated at 810 billion tons, while the volume of remaining recoverable reserves of low and medium viscosity oil is only 162.3 billion tons.

However, it is quite difficult to develop such fields, heavy oil is not mobile. To solve this problem, thermal methods are mainly applied to heavy oil to reduce viscosity, increase mobility and, consequently, facilitate production and increase flow rate. Common thermal methods (steam-thermal influence on the formation, steam-cyclic or vapor-gas treatment of bottomhole zone of wells, in-situ burning) do not always have high profitability. The most promising among such methods is the method of steam-gravity stimulation using 2 horizontal wells used in a pair, known as SAGD (Steam Assisted Gravity Drainage).

This method first appeared in Canada in the 80s of XX century, thanks to significant investments in research projects in the field of thermal methods, as well as with the development of horizontal drilling technology in Canada was developed technology of steam-gravity impact using a pair of horizontal wells, better known in the global industry as SAGD (Steam Assisted Gravity Drainage).

The method of paragravity impact on the productive reservoir is a relatively new direction in the development of fields with high-viscosity oil. Analysis of literature sources showed that this technology is increasingly used in the world.

Relevance of the work. Large oil and gas reserves have been found in Kazakhstan and the country has become one of the largest oil exporting countries at the current time and in the near future. According to some estimates, the volume of hydrocarbon reserves is 1.8% of the world's oil reserves.

In recent years, the strategic task of development of Kazakhstan's oil and gas complex is to stabilize and gradually increase oil production both by bringing new deposits and fields into development and increasing the efficiency of operation of old oil facilities.

In conditions of depletion of traditional hydrocarbon reserves, more and more attention is paid to fields with hard-to-recover reserves (HTR). HTR include heavy high-viscosity oil, the volume of which in our country is estimated at 934 million tons.

One of the most important components of oil reserves not only in Kazakhstan, but also in other producing countries of the world are fields with oil viscosity of more than 35 mPa*c. The size of reserves is about 810 billion tons, and the size of reserves of low and medium viscosity oils is about 162.3 billion tons.

The use of conventional, widely used technologies for extraction of high-viscosity oils has a low oil recovery factor (ORF) and consequently low profitability for the subsoil user, as well as environmental damage.

There are many methods for extracting high-viscosity oils, the most widespread of which are: - vapor gravity drainage, vapor injection of solvent, cyclic vapor injection and a number of others.

Justification of the need for this research work on the topic. The most promising for the production of high-viscosity oils with the lowest possible costs, is the method of steam-gravity drainage (SAGD), widely implemented in the oil fields of Canada. Natural gas-derived steam is injected into an upper well that runs approximately 5 to 10 meters above the production well. The steam heats and reduces the viscosity of the oil, which, along with the condensed steam, flows into the production well below. Because the oil is always in contact with the high-temperature steam chamber, heat loss is minimal, making this method of development economically viable.

One of the main limiting factors in the wide application of SAGD technology is the shallow depth of wells 500-600 m in which this method can be implemented. To solve this problem, it is necessary to ensure maintenance of high temperature of injected steam regardless of the well depth.

Information about the planned scientific and technical level of development. The technical solution proposed by the authors is innovative in nature, confirmed by a protected patent of the Republic of Kazakhstan and a number of scientific publications both in Kazakhstan and abroad. The proposed technical solutions will significantly affect the level of scientific and research work, provide a qualitative growth of scientific and technical potential.

The dissertation has a high significance in the national and international scale and will raise the status and prestige of the oil and gas industry of Kazakhstan in the world arena.

This scientific work is connected with the research work on GF IRN AR05135893 "Multidisplinary approach to optimization of steam-gravity drainage of oil using geomechanical calculations and changing the location of wells".

Information about metrological support of theses. The present study is based on the official terminology of the international organization of legal metrology. In the course of the research it is implied to use both new control and measuring instruments and instruments that have passed state verification during the period of operation. These

instruments shall comply with the requirements of the polar accuracy class and standard established by the "Law on Observance of Uniformity of Measurements". Analytical studies will be carried out in accordance with measurement techniques that comply with the said law. Depending on the graphical dependencies, the measurement indicators corresponding to the metrological rules and standards of the international system of SI units will be used.

Scientific novelty of the dissertation lies in the solution of technological and technical problems on bringing high-temperature steam to the productive layer, lying at a depth of 1000-1500 m, which will allow for the first time to apply the SAGD technology in Kazakhstan and provide priority on an international scale and apply the result of research to increase oil production in the fields of Kazakhstan with high-viscosity oil.

The object of the study is the method of steam-assisted gravity drainage (SAGD) to increase production of high-viscosity oil in the fields of Kazakhstan.

The subject of the study is "System of downhole thermoelectric module placed in the tubing string".

The purpose of the work is to expand the application of the method of steam-gravity impact (SAGD), for productive formations with high-viscosity oil at depths of 1000 - 1500 meters.

Objectives of the research:

1. Analysis of existing ways to expand the use of steam-assisted gravity stimulation (SAGD) on the productive formation with viscous oil.
2. Analytical studies of the process of maintaining a given temperature of steam along the wellbore at the method of SAGD with thermoelectric module and building a mathematical model in the program Eclipse.
3. Experimental studies of the steam temperature maintenance process on the physical well model at steam injection with and without downhole thermoelectric module.
4. Expected well flow rate at steam-gravity influence on productive formation by SAGD method with thermoelectric module. 4.
5. Calculation of expected economic efficiency of application of SAGD with thermoelectric module.

The main provisions put forward for defense:

1. A comprehensive approach to the study of the area of expansion of the application of steam-gravity impact (SAGD) on the productive formation with high-

viscosity oil is largely determined by the parameters of injected steam and heat losses along the wellbore.

2. technical solution to create a system of downhole thermoelectric module placed in the tubing string, which allows to reduce heat losses and bring saturated steam to the productive formation with the specified parameters of temperature and volume.

3. The main regularities of temperature regime changes along the wellbore influencing the expansion of the SAGD method application area by well depth were revealed.

Theoretical and practical significance of the work

Theoretical significance of the work lies in the innovative technology and technique of maintaining the temperature of injected steam at great depths for the SAGD method and the way to solve the problem of reducing heat losses along the borehole of horizontal wells.

Practical significance of the results lies in the creation of a system of downhole thermoelectric module, placed in the tubing string allowing to reduce heat losses and bring saturated steam to the pay zone with the specified parameters of temperature and volume, thereby solving the issue of expanding the scope of application of the SAGD method for deeper wells typical for the fields of Kazakhstan.

Approbation of the results of the dissertation work

The main results of the dissertation work were reported at the International peer-reviewed scientific journals included in the database Scopus/Web of Science (2021 - Cite Score 1.0 and 2023 - Q3), the International Conference Satbayev Readings "Innovative technologies - the key to successful solution of fundamental and applied problems in the ore and oil and gas sectors of the economy of the Republic of Kazakhstan" (Almaty, 2020), in the Proceedings of the International Satbayev Readings (Almaty, 2021), in the journals of Neft and Gas (Almaty, 2021). Almaty, 2020), in the Proceedings of the International Satbayev Readings (Almaty, 2021), in the journals Oil and Gas (Almaty, 2022), Mining Journal of Kazakhstan (№ 3 and № 5, Almaty, 2023), in the Bulletin of KBTU (Almaty, 2021).

Publications

The main results of the study are reflected in 10 scientific publications. Of them 2 articles were published in the journals included in Web of Science and Scopus databases. There are also 3 articles included in the publications approved by the Committee for Control in the Sphere of Education and Science of the Republic of Kazakhstan. One article was published in other scientific editions. In addition, the results of the study are reflected in 2 patents of the Republic of Kazakhstan and 2 reports presented at international scientific-practical conferences.

Structure and volume of the dissertation

The dissertation work consists of an introduction, 5 sections, conclusion, list of used sources of 98 names. The work is outlined on 108 pages, includes 62 figures and 23 tables.