THE CONCEPT OF SMART TECHNOLOGIES IN THE OIL AND GAS INDUSTRY

[1]Mirzakhalilova Damira Minnisalikhovna, [2]Vasser Polina Nikolayevna

[1]Candidate of Economic Sciences, Associate Professor of the Department of Economics of Oil and Gas, Branch of the Russian State University Oil and Gas named after Gubkin, Tashkent, Uzbekistan

[2]Student, Branch of the Russian State University Oil and Gas named after Gubkin, Tashkent, Uzbekistan

https://doi.org/10.5281/zenodo.7808790

Abstract. *The digital transformation of the oil and gas industry has many advantages and limitations, therefore, in order to assess the economic and technological efficiency, it is necessary to consider this tendency from the both sides. This article considers the introduction of smart technologies in the oil and gas industry, the technological and economic effect of the digitalization of oil and gas infrastructure, as well as the rationale for investment attractiveness for smart wells based on their performance.*

Keywords: *smart wells, digitalization, intelligent, deposit, efficiency, technology, net present value.*

Introduction

The XIX century was marked by significant changes in the oil and gas industry, and the introduction of intelligent systems plays an important role in the improvement and development of industry technologies.

The digital transformation of the oil and gas industry involves a new strategy for the development of the oil and gas complex, which provides for a transition to sparsely populated, and in the future to unpopulated technologies for the extraction and processing of hydrocarbons based on digitization and robotization of technological processes, especially in hazardous areas. The main digital technologies currently used in various sectors of the economy are: big data, neurotechnologies and artificial intelligence, distributed registry system, quantum technologies, industrial Internet of Things, robotics and sensor components, wireless communication technologies, virtual and augmented reality technologies. The use of some of these technologies makes it possible to create "intelligent wells" and "smart injection wells", bionic wells, "intelligent (digital) deposits", smart mobile workers (bots, Robotic process automation technology), underwater complexes for unmanned hydrocarbon production technologies in the oil and gas industry. These developments are necessary for implementation in the oil and gas industry for the intensification and automation of processes in the search and production of hydrocarbons.

Methods

Oil and gas technologies of the XXI century are characterized by a whole range of functions and capabilities, including "intelligent" models of productive formations, 3D identification of reservoir properties of the reservoir, 3D regulation of oil and gas field development, "intelligent" wells - smart wells. In world practice, the introduction of smart wells and smart deposits is the most successful. They are promoted by such foreign oil companies as Chevron, BP and Shell. Remote control of oil production facilities is provided at such fields, which reduces costs and increases the oil recovery coefficient. According to SaudiAramco, an oil company in Saudi Arabia, the use of plastic nanorobots in oil fields, which are in the final stages of development, will increase the oil recovery factor to 60-70 percent. According to Cambridge Energy Research Association (CERA), the use of intelligent technologies can improve the development of oil fields by 2-7%, reducing the costs associated with oil production by 25% [2].

An intelligent management system for the development of hydrocarbon deposits is understood as a system in which the development and implementation of measures to manage the processes of extracting hydrocarbons from the reservoir and preparing them for transportation are subsystems of intelligent decision support and risk management, where models of objects and/or processes formed on the basis of sensors are used to assess industrial processes. As it shown in the Figure 1, the intelligent well system is mainly composed of two parts: ground equipment and downhole equipment, including downhole information detection and acquisition system, production fluid control system, data information transmission system and uphole data analysis system [5,6,7,8]. The production fluid control system is an integral part of intelligent well technology. When the reservoir pressure is insufficient, the reservoir energy can be restored by regulating the flow rate. Thus, it can effectively control interlayer interaction, delay water breakthrough, reduce water content, increase the time of highly efficient reservoir development, optimize oil well production and increase oil and gas production.

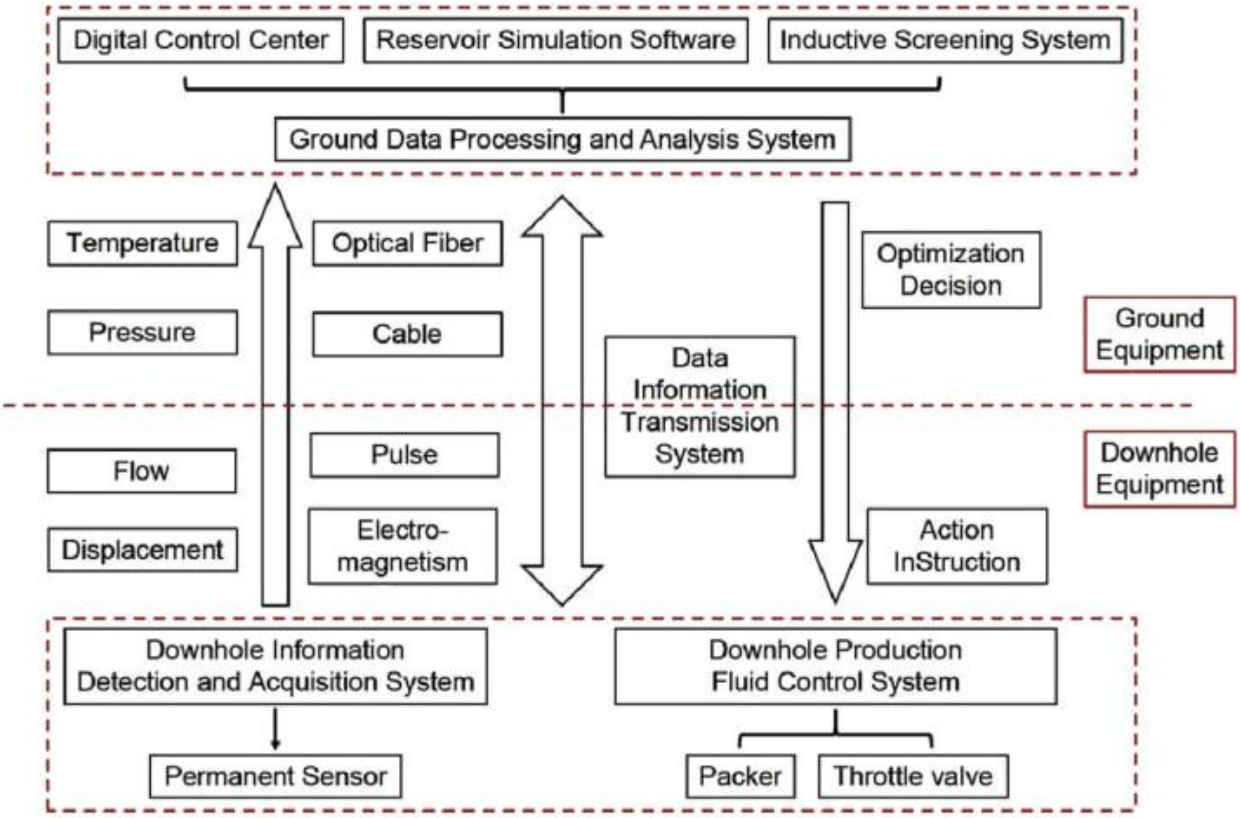

Figure 1. Architectural diagram of intelligent well technology

The importance of sensors in the Intelligent Well system cannot be overemphasized. Important real time and future decisions are based on comparisons of readings and measurements that are derived from the sensor, to the flowing reservoir model. For example, a downhole pressure sensor’s readings during production can be analyzed, and compared to the expected geothermal gradient. This can help to detect a zone of abnormal pressure (under-pressure or overpressure), thus preventing a catastrophe [1,4]. This system should support the adoption of effective management decisions both at the field level and at the level of the mining company and the company as a whole. The need to create an intelligent system at the field is determined by the growth of uncertainties and associated risks of natural (deep deposits with hard-to-recover reserves) and market (changes in supply/demand and fluctuations in hydrocarbon prices) nature and risks caused by the human factor, the emergence of new technologies and equipment for the production of hydrocarbons and controls over the development of deposits, significant volumes geological and field information and the use of various software and hardware complexes for their collection, processing, analysis and storage. The main task of the intelligent field management system is to provide coordinated support for effective decision–making at all levels of management to ensure the rational development and operation of deposits [3].

The most important function of an intelligent field management system is to control the development process. The purpose of monitoring is to control changes in the main properties of the deposit and its individual sections in the development process. Monitoring, as the most important function of control and management of the development of oil and gas fields, may depend not only on the geological characteristics of the fields, but also on the oilfield equipment used. In this case, in an intelligent field, monitoring functions can take place by equipment: field, field (area), well cluster, well elements (electric centrifugal pumps, sucker rod pumps, etc.) [9].

Results and discussion

An example of smart deposits is the exploitation of the Salym oil field by Salym Petroleum Development [10]. Integrated Production System Modeling software was launched in the Salym oilfields to improve oil production planning. Production wells, including water intake and water injection systems, have been equipped with this software. The information system Andon Board has been developed and introduced within the framework of this project. SPD specialists receive information in real time, process it using built-in well stock monitoring devices, determine the necessary adjustments for each well using an automatic control system. Thanks to this method, SPD has managed to improve production by 2–2.5% per year on average and reduced unscheduled downtime, and the average failure free performance period of the well equipment has increased [11].

In Uzbekistan, the Digital Field concept was developed by Uzbekneftegaz JSC. A Digital Modeling Center has been created at Uzbekneftegaz JSC, which is fully equipped with advanced world software, servers and computers, and a team of young specialists has been formed, consisting of professional personnel of the joint-stock company. In a short time, the specialists of the Digital Modeling Center have created digital geological models of more than 100 hydrocarbon deposits, digital hydrodynamic models of about 20 deposits in accordance with the latest industry requirements, and work in this direction continues [12].

At present, in order to implement the 1st stage of the Digital Field concept at collection points 1,3,4,6,9,10,12,14,15,20,22,24 and BT 5,17,19,30,34 belonging to the Shurtan field, temperature and pressure measuring devices, solar panels, as well as WI-FI radio relay transmitters, the Ubiquity AirFiber 5U bridge, and the technological parameters of collection points were installed using special software developed by specialists of UzLITIneftegaz JSC, were transferred to the central production dispatching service of the Shurtan oil and gas production department online.

Table 1.

Summary data on digitalization of some oil and gas facilities in Uzbekistan

Oil and gas industry facility	Works on digitalization
"Shurtan", "Southern Tandircha", "Zevarda", "Southern Kemachi", "Urtabulok", "Eastern Berdak", "Somontepa", "Denizkul", "Taylok", "Nizhny Surgil"	Work on the organization of a modern telecommunications network
"Shurtan"	Temperature and pressure measuring devices, solar panels, WI-FI radio relay transmitters, the Ubiquity AirFiber 5U bridge, and the technological parameters of collection points were installed using special software developed by specialists of UzLITIneftegaz JSC.
«Uchtepa»	FlowLink software for control accounting and provide automatic transmission of gas volume data from the autopilot to the dispatch service, excluding the human factor.
«Kuchlik oil depot»	The Jumo measuring device of German technology, capable of programming 5000 and 2000 cubic meters of vertical tanks and and being put online to the dispatch system.

According to the concept of "Digital deposit", work on full digitalization of all deposits of the republic will be carried out until 2026.

In order to obtain the results of observations on the economic effect of the use of smart wells, a synthetic reservoir model was selected based on the properties of the Brazil reservoirs, which are part of the reservoir (producer drainage area) studied with a maximum simulation time of 30 years and a water injection production method.

Table 2 shows the results obtained for the optimization of conventional well and smart well. It can be seen that smart wells are able to increase oil production and net present value when compared to the conventional well, while reducing water production in both controls, proactive and reactive. Water production is an important factor in offshore fields because of the need to do the water treatment, becoming extremely important since it reduces water production, as well as increasing oil production. The differences between the net present value of smart well and conventional well are also presented to evaluate the revenue available to be invested in smart completion and still be advantageous to use this costlier completion [4]. According to reactive control, which is carried out after the occurrence of some problems, for example, a drop in production, a change in the density of the drilling fluid, or fluid leakage from the well, a smart well can generate a net present value increase of $1.16 million compared to conventional well, while a proactive control which is based on non-stop monitoring of well performance showed a net present value increase of $1.50 million.

Table 2.

Results of production for conventional well and smart well

Probable Scenario	Oil Production (10^6 std m^3)	Water Production (10^6 std m^3)	Water Injection (10^6 std m^3)	NPV (US$ millions)	Δ NPV (US$ millions)
Conventional well	1.57	1.49	3.60	53.40	0
Smart well - Reactive	1.59	1.47	3.61	54.56	1.16
Smart well - Proactive	1.59	1.44	3.57	54.90	1.50

The next thing to consider is which type of control is most appropriate for a smart well. Table 3 presents the percentage of different types of completion for the two types of control; smart well in relation to conventional well. The results show that smart well are able to close valves with high water production, besides keeping others open with better relations between oil and water flow, increasing oil recovery and reducing water production and, consequently, increasing net present value. For smart well with reactive control, the valves are closed at different times, but all with the same optimal water cut, maximizing the net present value of the field. In the proactive control, valves performed proactively in relation to each other, because valves which started to decrease net present value closed the completion to increase revenue in other valves of the well [4].

Table 3.

Differences in indicators for smart wells in relation to conventional wells

Probable scenario	Oil production	Water production	Water injection	NPV
Smart – Reactive	+1.33%	-1.44%	+0.20%	+2.12%
Smart - Proactive	+1.21%	-3.98%	-1.03%	+2.73%

Thus, the results of the study of the probable scenario for oil production showed that the practice of proactive well control based on smart wells leads to a reduction in oil, gas and water losses based on the automation of the oil production process and the detection of ruptures in the oil and gas gathering network system allow to obtain an increase in the net present value, and therefore high economic effect, making smart wells a good investment compared to conventional wells. At the same time, there are a number of limitations that do not allow smart wells to be fully economically and technologically efficient, among them:

1. Input-output ratio. The cost of the whole intelligent completion system is high, even the application of one of the key technologies requires a high initial investment. For some wells with small production, there may be a smaller comparison between cost and benefit output, which in turn reduces the final economic benefits. Even some wells have an input-output ratio of less than 1, resulting in a loss. Therefore, when using the intelligent well technology, the expected production of the well is limited. In addition, the cost of intelligent well technology does not increase linearly, it has a higher investment in the initial stage. Even if the expected production of

the well is high and the daily production is insufficient, the investment return period will be prolonged, and the final economic benefit will be reduced.

2. Requirements for well conditions. Since the downhole space of the oil and gas well is small, and the intelligent well system has more equipment and facilities, there are certain requirements for the well condition. Intelligent wells are generally suitable for self-drilling wells, gas lift wells and installation of large displacement pump wells (such as electric submersible pumps). Non-self-injection wells need to be equipped with more wellbore tools, which will lead to further reduction of downhole space, affecting the installation of intelligent well equipment and tools. As a result, the intelligent well system cannot perform its full function or even function properly.

3. Technical research. The complexity of the intelligent well system is higher than any previous downhole tool, and the unpredictable downhole environment makes the development of the intelligent well system more difficult. Until today, technologies can't guarantee that any intelligent well system can improve production stably and safely [4].

Conclusion

The introduction of smart technologies in the oil and gas system is a priority in the development of the oil and gas industry. Equipping wells with smart technologies allows increasing the volume of oil production, reducing the unit cost of production, growth oil recovery by improving the quality of the well, increasing the productivity of oil and gas enterprises and thus increasing the level of labor productivity, freeing personnel from labor-intensive operations and establishing a high degree of safety at the oil and gas facilities.

Also, the introduction of smart technologies can improve not only operations directly in the field, but also activities in the field of transportation, preparation and processing of hydrocarbons. It should also be noted that the widespread introduction of intelligent technology, according to expert organizations, may increase global oil recovery from 30 to 50%. However, the initial parameters of oil and gas facilities are not always perfect for the introduction of smart technologies, therefore, for the speedy digitalization of the oil and gas industry, it is necessary to improve the technological capabilities of oil and gas facilities and continue developments in the field of smart technologies for their bilateral integration. Only with a harmonious interconnection between oil and gas infrastructure and smart technologies, the maximum technological and economic effects are possible.

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