ANNOTATION

Dissertation work of Balgaev Doszhan Ergenovich on the topic "Study of the process of operation of valve units of an improved design of sucker-rod borehole pumps" for the degree of Doctor of Philosophy (PhD) in the educational program 8D07110 - "Digital engineering of machines and equipment".

Relevance of the research topic. Kazakhstan has extensive hydrocarbon reserves and occupies one of the leading places in the world in terms of oil reserves. According to estimates by British Petroleum, as of the end of 2017, Kazakhstan is in 12th place in terms of proven oil reserves, and its share is 1.8% of world oil reserves.

In recent years, the strategic objective of the development of the oil and gas complex of Kazakhstan has been to stabilize and gradually increase oil production both by bringing new deposits and fields into development and by increasing the efficiency of operating old oil facilities.

As the service life increases, an increasing number of oil fields are switching to pumping hydrocarbon production. More than half of the world's operating wells are equipped with sucker rod pumping units (SRU). In particular, in the USA, 85% of the entire well stock (more than 470 thousand) is operated in this way, in Russia - about 53% (about 76 thousand), in Kazakhstan - about 65%. In the CIS countries, about 66% of oil fields are operated by downhole sucker rod pumping units (SRU), which is due to their high reliability and service life, structural simplicity, high reliability, non-scarcity and low cost of materials used in their manufacture, as well as ease of maintenance. These factors ensured the conservatism of the SRU design, which has not changed for a long time. An analysis of the state of development of oil fields in Kazakhstan shows that for individual fields, the use of downhole sucker rod pumping units with a balance drive (pumping units) is almost 100%. For example, these are Uzen, Karazhambas, Emba, etc., located mainly in the Mangistau region. Their number is several tens of thousands (according to some sources, over 65 thousand). Such a wide application of SSPPU is due to their high reliability and service life, ease of maintenance of both the surface drive (pumping unit) and downhole equipment (pumps, rods).

A review and analysis of the SSPPU operation in various operating modes shows that this type of production has become dominant in aging fields, as more than half of the world's operating wells are equipped with sucker rod pumping units (SSPPU). In particular, in the USA, 85% of the entire well stock is operated in this way, in Russia - about 53%, in Kazakhstan - about 60%.

Throughout the CIS countries, about 66% of oil fields are operated by sucker rod pumping units (SSPPU), which is due to their high reliability and service life, design simplicity, high reliability, non-scarcity and low cost of materials used in their manufacture, as well as ease of maintenance. These factors ensured the conservatism of the SShNU design, which has not changed for a long time.

Almost all mass-produced SShN use a ball valve unit, as they have a simple design and have proven themselves well in operation. SShN ball valves consist of a seat and a ball shut-off element.

The main idea of this scientific research is to increase the service life of sucker rod well pumping units for oil production by means of constructive improvement of the pump valve units.

Object and subject of research – Valve unit of well deep pumps used in oil fields of Kazakhstan for oil production.

The purpose of the dissertation is to increase the service life of sucker-rod pumping units for oil production by means of structural improvement of the pump valve units.

Research methodology. Empirical scientific methods in the form of applied scientific research aimed at setting up, studying, observing and measuring ongoing processes, modeling real operating conditions of the sucker-rod pump valves and conducting pilot tests.

The level of development of the research topic. The analysis of 8 thousand sucker-rod pump failures shows that the first place is occupied by failures associated with the breakage of the rod string, the second place - failures associated with the malfunction of the valve units and the third - failures due to the non-tightness of the cylinder-plunger pair. When pumping oil using sucker-rod pumps, about 15 - 30% of oil well shutdowns for routine repairs are associated with the replacement of sucker-rod pumps.

In accordance with GOST 31835-2012 "Borehole sucker-rod pumps. General technical requirements" sucker-rod pumps are produced in 9 standard sizes. The standard provides for the production of pumps with a nominal diameter of 27, 32, 38, 44, 57, 70, 95 and 102 mm. The efficiency of the SSHU in operation is significantly reduced due to low pump filling factors during the extraction of viscous oil. The main reason for this is the decrease in the flow rate of the valve units, which does not allow filling the cavity of the plunger pump in the allotted time. An assessment of the feed rates at many fields shows that their values do not exceed 0.4-0.5. Increased sand content and other mechanical impurities are the main reasons for increased wear of sucker rod pump elements and their failures. As a result, the inter-repair period is reduced, the number of idle wells increases, and the costs of underground routine repairs of wells increase.

Scientific novelty of the work: The increase in the volume of oil production in the world by pumping method due to the aging of oil fields is growing from year to year. In the volumes of pump production, the most widely used are SSHU, characterized by simplicity of design and reliability in operation. Analysis of the causes of SSHU failures showed that the total share of pump failures due to non-tightness of the plunger, valve pairs is about 15 - 30% of the total. In this regard, increasing the reliability of operation and increasing the service life.

Theoretical significance. The valve of the new design, unlike the serial SSHU valve, consists of 5 main elements instead of 4, while the body is made elongated with the addition of the height of the "turbulator". The developed "turbulator" is an additional element of the valve design, which has a 7.5 mm wide screw plate in the internal cavity, which ensures the overlap of 50% of the "turbulator" flow hole along the screw line and, as a result, the swirl of the liquid flow, due to which the rotation of the valve shut-off element and its landing on the seat in a "new" place are achieved.

The height of the "turbulator" is equal to two thicknesses of the standard valve seat. "Turbulators" are manufactured using additive technologies for creating a physical object based on an electronic model on a 3D printer using the FDM (Fused deposition modeling) layer-by-layer build-up method.

At the same time, the developed design of the SSHN valve unit has technical novelty, ease of implementation, which does not require significant changes in the serially produced pump valves.

Practical significance. Based on the results of the conducted patent, analytical, experimental studies and pilot tests, it was established that the developed design of the valve unit of the downhole sucker rod pump has a technical novelty, is easy to implement, and does not require significant changes to the pump valve. It was experimentally confirmed that the modified design of the valve by installing a flow "turbulator" that has a screw plate in the internal cavity, which ensures the overlap of 50% of the flow hole of the "turbulator" and causes a swirl of the liquid flow, due to which the rotation of the shut-off element of the valve and its landing on the seat in a "new" place is achieved. The conducted pilot tests (PIT) confirmed the operability of the new design of the valve unit in field conditions at the Uzen field.

Provisions submitted for defense:

1) The developed design of the valve unit of the sucker rod pump with a flow turbulator.

2) Mathematical model and results of physical experiment of studying the operation of valve units of new design of sucker rod pumps, taking into account the operating conditions of the pump.

3) Methodology of research in the field of hydraulic processes of operation of valves of borehole sucker rod pumps based on experimental bench studies

4) Methodology of conducting pilot and field tests of operation of valves of borehole sucker rod pumps

Implementation of the results of the work. The developed product in the form of a new design of the SSHN valve can be replicated in all oil wells of fields in Kazakhstan and the world, equipped with borehole sucker rod pumping units.

Work approval. The main results of the work were reported at international scientific conferences and discussed at scientific seminars. On the topic of the dissertation research, 5 printed works were published in scientific journals, including 2 articles in a journal indexed in the Scopus database.

1) Zaurbekov S.A., Akanova G.K., Balgayev D.Y., Zaurbekov K.S.Extension of operational life of ball valves in piston and plunger pumps «Статья». MIAB. Mining Informational and Analytical Bulletin, 2021;(7):165-1750.https://www.giabonline.ru/files/Data/2021/7/165-175.pdf . Scopus Industrial and Manufacturing Engineering – 27% процентиль

2) B.A. Myrzakhmetov, T.A. Kuandykov, B.K. Mauletbekova, D.Y. Balgayev, J.B. Nurkas. Multifunctional valve for the arrangement of submersible downhole pumps in downhole oil production «Статья». NEWS of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technical sciences. ISSN 2224–5278. Vol 2. N 464 (2024), P 156–168. https://doi.org/10.32014/2024.2518-170X.400. Scopus Geotechnical Engineering and Engineering Geology – 36% процентиль

3) Исмаилова Д.А., Заурбеков С.А., Балгаев Д.Е., Заурбеков К.С. Обзор и анализ отказов скважинных штанговых насосных установок. “Горный журнал Казахстана” №3 (215) 2023г. с. 39-43. ISSN 2227-4766. https://minmag.kz/ru/2023/04/14/%e2%84%963-2023/

4) K.S. Zaurbekov, S.A. Zaurbekov, D.Y. Balgayev, A.V. Sladkovsky, Hydrodynamic simulation of the steam-assisted gravity Drainage method for different reservoir thicknesses Using eclipse. NEWS of the National Academy of Sciences of the Republic of Kazakhstan. SERIES OF GEOLOGY AND TECHNICAL SCIENCES. ISSN 2224-5278. Vol 3, N 459 (2023), 60–69. https://doi.org/10.32014/2023.2518-170X.299

5) Заурбеков С.А. Заурбеков К.С., Балгаев Д.Е. Расширение возможности применения гравитационного дренирования с закачкой пара (SAGD) и закачки пара с растворителем (ES-SAGD). «Горный журнал Казахстана» №7 (219) 2023г., стр. 40-45. ISSN 2227-4766. https://minmag.kz/ru/2023/08/08/%e2%84%967-2023/

Structure and volume of work. The dissertation consists of an introduction, four sections, and a conclusion. The total volume is 131 pages and includes 39 figures, 23 tables, and 7 appendices.