

Processes of vibroimpact treatment of wells

Lilia Zariipova^{1*}, and *Vladimir Shaydakov*²

¹Institute of Oil and Gas FSBEI of HE "Ufa State Petroleum Technological University", (Branch in the City of Oktyabrsky), 54a, Devonskaya Street, Oktyabrsky, Republic of Bashkortostan, 452607, Russia

²Ufa State Petroleum Technological University, 1, Kosmonavtov Street, Ufa, Republic of Bashkortostan, 450064, Russia

Abstract. The article presents the results of statistical processing of patent and scientific and technical information published in Russia, Great Britain, China, USA, EU countries, Japan on the problem of vibration shock treatment of injection wells, which is used to clean the bottom-hole formation zone from mechanical impurities, corrosion products, asphalt resin paraffin oil components. It was revealed that about 90% of the information is presented in journal articles, conference materials and patents. To a lesser extent, information is presented in books and dissertation research. There are practically no educational and methodological publications. The publication activity is devoted to the oscillatory movement of rock particles in a productive formation, the effect on rheological properties, the reduction of hydraulic resistance, the destruction of oil-water emulsions, the effect on the deposition of salts and paraffins.

1 Introduction

Patent and scientific and technical analytics occupy an important place in modern processes of work on innovative projects. It allows, first of all, to assess the relevance of research areas. It is justified to form a research program, to establish the prospects for development work. It becomes possible to reasonably identify competitive aspects of improved and newly created equipment. Considering that modern promising technical and technological developments most often appear at the junction of various areas of science and technology development, this analytical approach, with scientifically based statistical processing, gives specialists an accurate forecast of equipment and technology improvement, including taking into account rapidly changing operating conditions. An important aspect of statistical research of patent and research information is the ability to assess which components of the equipment require constructive changes in the first place. The totality of these studies allows us to reach promising "pioneer" solutions.

Russia's main oil fields are in the final stages of development. Maintaining production volumes and reducing the rate of decline requires the introduction of modern science-based technologies. The reservoir pressure maintenance system with regulated injection into the

* Corresponding author: Lilyabert31@mail.ru

reservoir in many ways makes it possible to extend the economically justified cost-effective period of hydrocarbon production [1-4]. Injection wells are an important element in the overall chain of the reservoir pressure maintenance system. Failure to comply with the quality requirements of the injected liquid, which contains residual oil, mechanical impurities in the form of inert particles and corrosion products, clogs the bottom-hole zone of wells [5-7]. The problem of reducing the intake capacity of injection wells, which is observed everywhere, changes the hydrodynamic mode of operation of oil reservoirs, which leads to a decrease in hydrocarbon production [8-10]. Based on patent and scientific and technical information, this article analyzes approaches to restoring the parameters of injection wells by means of vibro-wave treatment, cleaning their bottom-hole zone from components accumulated during injection.

2 Methods and Materials

A search was conducted for scientific and technical information on the topic "Vibro-wave treatment of wells in the process of drilling and oil production". Sources of information to search for: scientific electronic library <https://elibrary.ru> and <https://www.sciencedirect.com> / – the website providing paid access to scientific publications belongs to Elsevier publishing house. Sources for searching patent information: databases of the Federal Institute of Industrial Property (FIPS) - <http://www.fips.ru>, databases of the European Patent Office (European Patent Office) ep.espacenet.com. When searching for scientific, technical and patent information on the above-mentioned databases, requests were made for all available data on the hydromechanical effect on injection and production wells (patents, articles in journals and conference materials, books, monographs, a collection of works, reports of research institutes and design organizations).

The culling of accidentally trapped materials was carried out. In the resulting general array, the main physico-chemical processes embedded in each technical solution, a specific object and the direction of these processes, and the final result were identified. Special emphasis was placed on materials with confirmation of implementation and pilot tests. Dissertation research was analyzed separately for scientific novelty.

Previously conducted analytical and laboratory studies with the participation of the authors allowed an objective approach to the choice of research directions. Field experiments and significant implementation of the developed technical means and technologies at the facilities of the deposits of the Urals and the Volga region confirmed the correctness of the chosen directions [11-16].

3 Results and Discussion

According to the Elibrary electronic library, 497 papers have been published in Russia on the topic of vibro-wave well treatment. These are patents, articles in journals and conference collections and proceedings of various organizations, books, dissertations, scientific and technical reports, manuscripts in paper and electronic versions. (Figure 1).

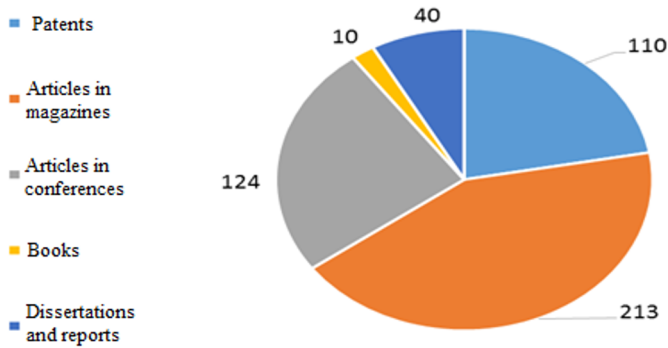


Fig. 1. Amount of published scientific information on wave well treatment.

According to the Sciencedirect foreign database, 211742 papers have been published on this topic, the distribution schedule by year is shown in Figure 2.

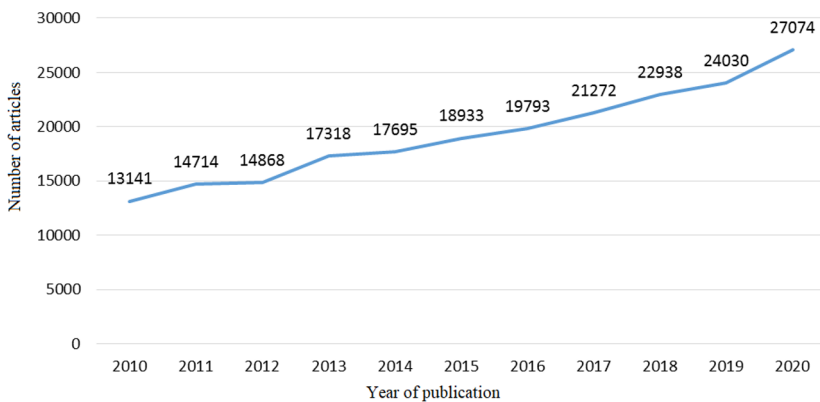


Fig. 2. Amount of published scientific information on well wave treatment over 10 years.

According to the results of the analysis, it was found that the largest number of publications falls on scientific articles (about 70 percent of the total amount of information in Russia). Many times more information is published in foreign journals. Over the past 10 years, the number of foreign published articles has doubled and tends to increase [11-17]. A significant number of foreign publications are of an advertising nature. There are many materials describing the design and technological features, but they are scattered in nature. There are no analytical reviews on this topic.

The results of the patent search are shown in Figure 3. According to the data presented, it was revealed that Russia, Great Britain, China, the USA, the EU countries, Japan, and Ukraine are developing in this direction. According to FIPS, 194 patents have been registered in Russia.

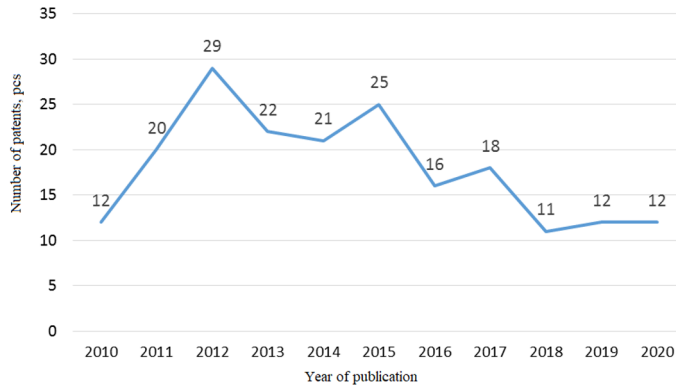


Fig. 3. Number of patents on vibration-wave treatment of wells.

The result of the patent analysis conducted on the databases of the Federal Institute of Industrial Property and the European Patent Office showed that over the period 2010-2020 there were more than 200 patents, the largest part of which belongs to Russia (more than 90 percent). The largest number of patent publications occurred in the period from 2012 to 2015. Based on the general distribution of the number of patents, it is natural that the Russian Federation is engaged in the study of new methods of well wave processing. Moreover, the number of patents is methodically decreasing. However, the number of other publications is growing. The largest number of patents are devoted to devices. Methods and technologies are covered to a lesser extent. Due to the peculiarities of downhole equipment, the design of the proposed technical means is not complicated enough. This allows for relatively high reliability in downhole conditions. There is very little educational and methodological literature. Moreover, the published materials for students are outdated in terms of content and methods of presentation. There is little coverage of new promising developments in them. There are no electronic materials that would use modern electronic methods of presenting educational information using multimedia systems.

According to the thematic focus, the publications provide information on the impact on the bottom-hole, productive formation in order to destroy the already formed complex deposits including oil, asphalt-resin-paraffin deposits, mechanical impurities, organic salts. A significant number of publications are devoted to the effects on the rheological properties of borehole fluids, which are optimized by vibro-wave action. In part of the work, materials on effects in the low frequency range are presented. To a greater extent, high-frequency exposure using electrohydraulic devices lowered on a cable has been studied. In the study of this area, the palm belongs to domestic specialists. In recent years, publication activity has increased on complex vibro-wave treatment of wells using highly effective chemical reagents, temperature exposure, magnetic, electromagnetic treatment, gas injection, foam compositions, surfactants. These publications are presented in the form of experimental field materials. However, there are no articles describing the comparative results of various tests of similar technical means and technologies according to the principle of operation.

In foreign practice, a large number of studies are aimed at mathematical modeling of the processing of the bottomhole zone. Models describing the processes in various reservoirs are presented. Promising research aimed at predicting the effectiveness of processing the bottomhole zone based on neural networks.

The patent and scientific and technical information focuses on the processes of vibration shock treatment of the bottom-hole formation zone. It is shown that vibration impact is more effective compared to repeated depression on the productive layer. The research has established the prospects and versatility of hydromechanical and electrohydraulic vibrator

designs. Simultaneous acid and vibration shock treatment increases the efficiency of injection wells by up to 90%. Good results have been achieved with the injection of energy-releasing binary mixtures. The analysis of dissertations on the vibro-wave topic showed that their main number is devoted to the impact on the bottom-hole zone of the formation in order to increase the productivity of producing wells and the intake capacity of wells of the reservoir pressure maintenance system.

The following processes are investigated in the analyzed materials:

- Prevention and reduction of the intensity of deposition of inorganic salts and asphalt resin paraffin deposits.
- Destruction of oil-water emulsions.
- Impact on the rheological properties of reservoir fluids.
- Vibro-wave effect on the bottom-hole zone of the formation, reducing hydraulic losses and increasing the capacity of injection wells.
- Investigation of the processes of vibration of rock particles ensuring effective cleaning of the bottom-hole zone of the formation.

Modern statistical methods using nonparametric statistics make it possible at all stages of processing the bottomhole zone to predict efficiency, control the process, and select processing parameters for specific rocks forming a productive formation.

4 Conclusion

- A statistical analysis of patent and scientific and technical information on the problem of vibro-wave treatment of wells published in Russia, Great Britain, China, the USA, the European Union, and Japan has been carried out. The leading position of specialists of the Russian Federation has been established.
- The main directions of the processes described in the studied sources are revealed. The bulk of the materials under study are dominated by processes associated with the effect of mechanical impurities, inorganic salts and asphalt resin paraffins on deposits, and rheological properties of reservoir fluids.
- The prospects of complex vibro-wave action together with chemical methods, thermal, biological treatments of the bottomhole zone of the formation are noted.
- Modern methods of mathematical modeling are promising for predicting the results of impact on the bottom-hole zone using neural networks.
- In order to develop and improve the technology of vibro-wave impact on the bottom-hole zone and improve the quality of training of specialists, there is a need for modern educational and methodological literature in this area.

References

1. E.M. Abbasov, N.A. Agaeva, Propagation of the constructed of pressure waves in fluid with the account dynamic connection of system the well-formation, SOCAR Proceedings, **1**, 77-84 (2014)
2. S. Mingulov, V. V. Mukhametshin, L. Kuleshova, A. Gizzatullina, R. Gilyazetdinov, Technology of pumping production of high-viscosity oil with injection of coolant to the bottom through hollow rods. E3S Web of Conferences, **498**, 03004 (2024)
3. C. Perez-Arancibia, E. Godoy, M. Duran, Modeling and simulation of an acoustic well stimulation method, Wave Motion, **77**, 224-228 (2018)
4. R.N. Gataullin, Intensification of oil production using wave stimulation methods on productive formations, SOCAR Proceedings, **2**, 78-90 (2020)

5. C. Calabrese, M. McBride-Wright, G.C. Maitland, J.P.M. Trusler, Extension of Vibrating-Wire Viscometry to Electrically Conducting Fluids and Measurements of Viscosity and Density of Brines with Dissolved CO₂ at Reservoir Conditions, *Journal of Chemical & Engineering Data*, **64(9)**, 383-384 (2019)
6. J.-P. Berenger, A perfectly matched layer for the absorption of electromagnetic waves, *Journal of Computational Physics*, **114(2)**, 185–200 (1994)
7. A. C. T. Aarts, G. Ooms, K. J. Bil, E. T. G. Bot, Enhancement of liquid flow through a porous medium by ultrasonic radiation, *SPE Journal*, **4(4)**, 321–327 (1999)
8. M.Ya. Khabibullin, R.I. Suleimanov, D.I. Sidorkin, I.G. Arslanov, Parameters of Damping of Vibrations of Tubing String in the Operation of Bottomhole Pulse Devices, *Chemical and Petroleum Engineering*, **53**, 378-384 (2017)
9. A. Aslanyan, L. Parnovski, & D. Vassiliev, Complex resonances in acoustic waveguides, *The Quarterly Journal of Mechanics and Applied Mathematics*, **53(3)**, 429–447 (2000)
10. R.T. Akhmetov, V.V. Mukhametshin, L.S. Kuleshova, O.A. Grezina, P.M. Malyshev, The generalized correlating function of capillary curves and the relationship of the filtration-capacitive parameters of reservoirs in Western Siberia with the size distribution of pore channels, *Journal of Physics: Conference Series (International Conference on Information Technology in Business and Industry (ITBI 2020))*, **1661**, 012016 (2020)
11. V. Shchetnikov, V.V. Mukhametshin, L. Kuleshova, R. Gilyazetdinov, M. Veliev, A. Gizzatullina, Intensification of oil production using enzyme solutions, *E3S Web of Conferences*, **494**, 02008 (2024)
12. R.I. Suleimanov, L.Z. Zainagalina, M.Ya. Khabibullin, L.M. Zaripova, N.O. Kovalev, Studying heat-affected zone deformations of electric arc welding, *IOP Conference Series: Materials Science and Engineering*, **327(3)**, 032053 (2018)
13. R.I. Suleimanov, M.S. Gabdrakhimov, M.Y. Khabibullin, L.M. Zaripova, E.R. Vasilyeva, The study of hydraulic hammer device in drilling tool assembly in hydraulic rotary drilling, *International Journal of Engineering and Technology*, **7(2)** (2018)
14. L.M. Zaripova, M.S. Gabdrakhimov, A mathematical model of the pulsator for cleaning paraffin deposits of pipelines and downhole equipment, *Journal of Physics: Conference Series*, **1333(3)**, 032095 (2019)
15. L.M. Zaripova, M.S. Gabdrakhimov, Restoration of intake capacity of injection well by vibrations, *IOP Conference Series: Earth and Environmental Science (International Conference on Innovations and Prospects of Development of Mining Machinery and Electrical Engineering*, **378(1)**, 012120 (2019)
16. R. Kadyrov, V.V. Mukhametshin, R. Gilyazetdinov, D. Kobishcha, Technical and technological justification of repair and insulation works at oil fields of the Republic of Tatarstan using special compositions, *II International Scientific and Practical Conference “Energy, Ecology and Technology in Agriculture” (EEA2023)*, **480**, 01015 (2024)
17. S. Mingulov, V.S. Mukhametshin, R. Vafin, R. Gilyazetdinov, D. Kobishcha, The effect of the viscosity of borehole products on the operation of pumping equipment and the coefficient of oil recovery, *E3S Web of Conferences*, **494**, 02010 (2024)