ANNOTATION

Thesis submitted for the degree of Doctor of Philosophy (PhD) by specialty 6D070800 - Oil and Gas Business

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Improving the quality of well completion using effective cementing materials

The relevance of the work. One of the ways to solve the problems of improving the quality of well completion is to prevent complications arising at various stages of well construction, especially during casing cementing. Poor cementing can have various consequences, such as the need for additional costs for repairing cementing, stopping oil production during well operation, reducing the effectiveness of the technologies used to increase well productivity. A leakage of the cement ring can lead to self-killing of wells and, moreover, to their elimination due to the deterioration of the technical condition. Therefore, to improve the quality of cementing wells, it is necessary to improve the technique and technology of cementing, as well as the formulation of buffer and cementing solutions using effective chemical additives.

Despite the progress achieved in well cementing, there are a number of problems associated with the presence of low pressure formations, loss of fluid circulation, gas and water migration, as well as high mechanical loads on cement stone.

One of the most important tasks during cementing is to preserve reservoir properties and reduce the negative impact of process fluids on the reservoir.

The contamination level of the reservoir depends on the types of fluids and solutions used, the physical properties of the reservoir, and the method of pumping wells.The choice of solutions depends on the geological features of the reservoir structure, which include the rock properties and the properties of pore fluids, reservoir temperature and reservoir pressure. A negative impact on productive formations is exerted during all technological operations associated with the completion stage, including the initial opening, cementing and casing perforation. At the same time, formation contamination during cementing may be the most dangerous, since cement hardening products with a colloidal degree of dispersion enter into the reservoir with cement filtrate and are able to form highly viscous and strong structures of hydration products in the pores of the bottomhole formation seams which are able to drastically reduce reservoir permeability. According to many researchers, a decrease in the permeability of productive strata when exposed to cement filtrate may exceed 50%, which will adversely affect the productivity of the well. Therefore, the issues of reducing the negative impact on the productive layers of the cement filtrate are undoubtedly highly relevant.

At the same time, the most effective technique for reducing the effect of formation contamination is minimization of the water loss of cement mortars.

It cannot be denied that in this direction, various types of cement slurries and chemical additives that reduce water loss are being studied and developed.However, many reagents, fluid loss reducers have a negative impact on other technological parameters of the cement slurry or do not provide the necessary water loss of the cement slurry. Therefore, the development of effective cement slurries with multifunctional additives is an important task for improving the quality of well completion.

The purpose and objectives of the study is to reduce the water loss of cement slurry to improve the quality of injection wells through the use of new grouting materials with high water retention capabilities based on the integrated use of modern methods of testing of cement materials.

To achieve this goal the following tasks are solved:

1. The analysis and synthesis of the current state of the problems of cementing casing columns of oil and gas wells were conducted.

2. The substantiation of requirements for grouting materials to improve the quality of well cementing was carried out.

3. The most effective additives of water loss reducers of cement mortars were investigated and identified.

4. The formulation of the cement slurry with low water loss was developed.

5. The technology of application of cement slurries with reduced water loss wasrecommended.

Methodology of the study. The research methodology consists in analyzing the state of the problem, theoretical substantiation of the working hypothesis, analyzing and searching for the necessary reagents and materials, substantiating the methodological aspects of experimental studies using standard and original instruments and installations, processing and analyzing the results obtained**.**

The scientific novelty of the thesis. The novelty of the thesis is that for the first time the influence of the ПАК polyelectrolyte on the technological properties of cement slurries was studied. Also for the first time, we studied the effect of joint disintegrating treatment of powdered cationic polyelectrolyte with cement on the filtration properties of cement slurries. Also for the first time, the relationship between the kinetics of structure formation, the decrease in the hydrostatic pressure of the cement slurry column on the reservoir and the likelihood of gas burst through the cement slurry using new polyelectrolytes was established, which made it possible to justify the effectiveness of the ПАК polyelectrolyte to prevent gas manifestation through the cement slurry**.**

Scientific provisions for the defense

1.The rationale for the use of cationic polyelectrolytes to reduce water loss cement slurries and the results of experimental studies of cement mixtures based on Portland cement with the reagent ПАК, plasticizers and other modifying additives.

2.The composition of the cement slurry with low water loss and technological properties that meet the requirements of GOST, API. ISO

3.Technology for production of cement material by disintegrating treatment of powdered cationic polyelectrolyte together with cement.

4.The relationship between the kinetics of structure formation, the fall of the hydrostatic pressure of the column on the reservoir and the likelihood of gas rupture through the cement slurry during the WOCand the results of studies of the effect of cationic polyelectrolytes on the mechanism of gas manifestation during the WOC.

Practical significance

The practical significance of the work lies in the fact that, on the basis of laboratory experiments, the effectiveness of the use of the ПАК polyelectrolyte as an additive to the loss agent of cement mortars, which simultaneously prevents gas manifestations during the WOC, was determined. The technology of obtaining cement slurry with reduced water loss containing ПАК reagent according to disintegrating technology is substantiated.

Personal contribution of the author is:

- in the formulation of research tasks and the justification of methodological approaches to their solution;
- in the review of literary sources and the synthesis of the data;
- in the search and analysis of patents for obtaining cement slurries with low water loss;
- in the formulation and conduct of experiments and the subsequent processing of the results;
- development of cement slurry with low water loss;
- in filing an application for obtaining a patent for the invention of a cement slurry with low water loss.

Approbation of work.

The main results of the thesis were reported and discussed at regional, international scientific and technical conferences and symposia, including the international scientific and technical conference "Exploration and oil and gas business in the XXI century " (Almaty, 2016), "Modern technologies in the oil and gas business" (Ufa 2017, 2018), I-symposium of the Department "Petroleum Engineering" (Almaty, 2018).

Publications.

On the topic of the thesis 11 articles were published. Including:

4 articles in the republican specialized editions recommended by by the Committee for the Control of Education and Science of the Republic of Kazakhstan;

2 articles in an international magazine included in the Scopus database (PollutionResearchPaper (IF 0.25), KeyEngineeringMaterials (IF 0.29));

5 articles were published in materials of international conferences.

Also 1 application was filed for obtaining a patent (registration No. 2018/03071, dated May 15, 2018).

Structure and scope of the thesis.

The thesis consists of an introduction, five chapters (sections) with conclusions on each of them, conclusion, list of references and applications.

The thesis is presented on 134 pages of computer typing, including 37 figures, 44 tables, the list of sources used consists of 154 titles; there are 4 applications in the research work.

Summary of the dissertation.

The introduction substantiates the relevance of the dissertation work and presents its main provisions**.**

In the first chapter of the thesis, an analysis of the state of the problem is given, the significant factors causing problems during the injection of wells are identified and considered**.**The analysis of the geological and technical conditions of the construction of wells (for example, oil and gas fields of the Republic of Kazakhstan, in particular Amangeldy, Uzen) was carried out and the complications of cementing associated with the filtration characteristics of cement mortars were also reviewed.The same chapter provides an analysis of methods and technologies for improving the quality of cementing using cement slurries..

In the second chapter, the filtration and water separation processes in cement-water suspensions and the factors that determine these processes are theoretically considered. The analysis of methods for reducing the water loss of cement mortars, using various technologies and chemical reagents is alsogiven.

The third chapter is devoted to the substantiation of the working hypothesis and objects of research, the justification and development of methods for studying the filtration properties of cement mortars, as well as methods for processing the results of experimental studies.

The fourth chapter is devoted to experimental research. It should be noted a large and comprehensive set of studies of all significant properties of cement slurries, including both standard experiments on modern devices and installations, carried out in accordance with Russian and international standards (GOST, API, ISO), and experiments conducted on the original installations.The conducted studies became the basis for the development of new effective formulations of cement slurries using polyelectrolyte reagents, justified in the third chapter of the thesis. Many of the results obtained have a scientific and technical novelty, and were performed for the first time.

The fifth chapter is devoted to the results of the introduction of a new cement slurry formulation. A complex of experimental studies showed that polyelectrolyte reagent allows to obtain effective cementing solutions that ensure the normal cementing process and the well fixing quality exceeding.

In conclusion, the main results and conclusions on the thesis work are described.