ABSTRACT

Dissertation work by Murad Yusif ogly Kuliyev on the topic: "Improvement of drilling technology providing improvement of quality of fixing wells on deposits of Western Kazakhstan", submitted for the degree of Doctor of Philosophy (PhD) in the educational program 8D07210 – "Oil and Gas Engineering".

**Assessment of the Current State of the Addressed Scientific or Scientific-Technological Problem**

The accumulated experience from scientific research aimed at improving the quality of casing fixation, with a focus on enhancing the adhesion between cement slurry, casing, and the rock formation, shows that the efficiency of these operations largely depends on the mechanism of action of various fillers that contribute to increasing the strength of the cement stone.

Significant contributions to the development of cement slurry technology for casing fixation have been made by international researchers such as F.A. Agzamov, O.K. Angelopulo, R.G. Akhmadeev, B.Sh. Akramov, A.I. Bulatov, I.I. Vakhrameev, V.I. Krylov, B.M. Kurochkin, M.R. Mavlyutov, A.Kh. Mirzadzhanzade, G.M. Efendiev, V.N. Polyakov, K.V. Strizhnev, Z.Z. Sharafutdinov, A.A. Yakovlev, among others.

Research on the causes of cement slurry losses during well cementing and existing technologies for their elimination is associated with domestic scientists such as B.S. Izmukhambetov, B.T. Ratov, B.T. Umraliev, U.S. Karabalin, and others.

Despite the considerable volume of research conducted to date, there is still no unified view in the scientific literature on the comprehensive measures required to improve the quality of wellbore wall cementing. The search continues for the most optimal compositions from both economic and environmental perspectives. Therefore, there is a need for research into the use of local raw materials as additives, considering their cost-effectiveness and accessibility.

**Relevance of the Work.** Currently, targeted global research is being conducted to enhance the strength of cement stone in order to reduce its permeability, ensuring effective zonal isolation and strong bonding with both the casing and the rock formation.

Accordingly, special attention is given to creating high-strength cement slurry to improve the sealing of the annular space under the conditions of multilayer reservoirs in the fields of Western Kazakhstan.

In Kazakhstan, particular attention is paid to ensuring the long-term operability of oil and gas wells by enhancing the strength of cement stone behind the casing. In well cementing, key focus areas include technological improvements in methods for regulating the properties of cementing systems to ensure high-quality casing under complex conditions, which is especially relevant to Kazakhstan. This also includes developing compositions for special technological fluids and recommendations for their application.

One of the most critical tasks is the creation or improvement of technology, including the development of high-strength cement slurries for well casing. This remains a priority and an urgent challenge for the oil and gas industry.

Thus, improving well cementing technology remains a relevant and vital problem for the oil and gas sector.

**Objective and Research Tasks**

The objective of this research is to enhance the efficiency of well construction by improving cement slurry formulations under complex geological and technical conditions in Western Kazakhstan.

To achieve this objective, the following research tasks were undertaken:

1. A comprehensive review of international practices in the development of information analysis and decision-making systems aimed at improving wellbore integrity in complex geological environments;
2. An investigation into the influence of expanding additive calcium oxide (CaO) content on the properties of cement slurry, along with the development of a novel cement blend incorporating porphyrite to enhance the strength characteristics of the cement stone;
3. An experimental study on the effect of various additives on the compressive strength and bonding of the cement stone to the casing. Development of recommendations, including the assessment of the use of a 0.2% high-viscosity aqueous polyacrylamide solution as a spacer fluid to improve casing fixation quality;
4. The development of a methodology for assessing the risks associated with poor-quality cementing.

**Object of Research:** The object of this research is the isolation of multilayer hydrocarbon reservoirs within permeable rock intervals in the Western Kazakhstan region. Special attention is given to ensuring reliable zonal isolation during well cementing under complex geological formation conditions. The study takes into account the specific geological and technological characteristics of the region in order to enhance the effectiveness of wellbore integrity.

**Subject of Research**: The subject of this research is the analysis of the impact of porphyrite powder fines (PPF), containing active components, on improving the strength of the cement sheath and ensuring the sealing of the annular space after casing cementation.

Particular attention is paid to evaluating the effectiveness of expanding additives capable of compensating for cement shrinkage, as well as gas-blocking agents and plasticizers that enhance the structure and homogeneity of the cement slurry.

The dissertation also examines the influence of a novel spacer fluid composition specifically, a 0.2% high viscosity aqueous solution of polyacrylamide designed to remove filter cake from the wellbore walls, thereby promoting better bonding of the cement slurry with the formation and casing surfaces.

A comprehensive study of all these components allows for an assessment of their contribution to improving the reliability of wellbore integrity and the long-term durability of the cement sheath.

**Research Tools.** The solution to these tasks is based on general principles of scientific research methodology, including the analysis and synthesis of literary sources, theoretical, laboratory, and industrial data focused on improving primary cementing quality. The dissertation analyzes results from experimental studies using

modern control and measuring devices, including specially designed equipment. Cement properties were determined using standard research methods. Experimental data were processed using methods of mathematical statistics.

**Research Methodology.** The dissertation employs methods of mathematical statistics, modeling, and experimental research, as well as comparative analysis of factual materials related to the study of cement slurry properties based on local raw materials, accounting for their sealing capacity. Theoretical research was also conducted to evaluate key factors affecting casing quality in permeable rock formations.

**Tasks Addressed:**

1. A study of global practices in the development of information analysis and decision-making systems aimed at enhancing the effectiveness of wellbore integrity in complex geological conditions;
2. A detailed analysis of the impact of calcium oxide (CaO) expanding additive content on the properties of cement slurry, as well as the development of a new cement composition incorporating porphyrite to improve the strength of the cement sheath;
3. Experimental investigations into the effect of various additives on the strength and bonding of the cement sheath with the casing, along with a detailed analysis of the use of a 0.2% high-viscosity aqueous polyacrylamide solution as a spacer fluid and its impact on the quality of casing support;
4. Development of recommendations for a methodology to assess the risk of poor-quality cementing.

**Scientific Novelty.** The scientific novelty of the dissertation lies in the enhancement of foundational and methodological approaches for studying the impact of various factors on cement slurry quality indicators:

1. An improved technology has been proposed to enhance the bonding of the cement sheath with the casing and wellbore walls by introducing expanding agents—namely, calcium oxide (CaO) and porphyrite—into the cement slurry;
2. A new spacer fluid composition has been developed, consisting of a 0.2% aqueous solution of polyacrylamide based on hydroxyethyl cellulose, a structuring additive (aluminum sulfate $Al_2(SO_4)_3$), and a bridging agent (IKKARB-75);
3. A novel cement slurry formulation has been proposed with the addition of gas-blocking agents to ensure effective zonal isolation in gas wells;
4. Well classification based on cementing quality and associated risks has been carried out, allowing for identification of wells located in zones of acceptable or unacceptable cementing risk.

**Practical Significance.** The practical significance of the research results lies in the development of a technology incorporating a new approach to cementing quality, and in determining the rheological and physico-mechanical properties of cementing slurries for maximum effectiveness in zonal isolation under specific drilling conditions using locally sourced fillers (porphyrite from the Karatau deposit) to increase cement stone strength.

**Reliability of Results.** The reliability of the research is confirmed by real-world implementation of the proposed cementing technologies and cement slurry at facilities operated by JSC "Ozenmunaigas," JSC "Mangistaumunaigas," and JSC "Maten Petroleum," using the developed high-efficiency cement slurry to improve bonding between cement stone, casing, and formation.

**Author's Personal Contribution**

Based on the scientific results of the research and the developed measures aimed at improving annular space sealing during casing operations:

- A high-efficiency cement slurry containing porphyrite was introduced;
- An expansive cement was implemented for isolating permeable formations during the cementing of multilayer reservoirs. The use of calcium oxide increased the corrosion resistance of the cement stone by 11–13% and improved bonding with casing and formation by 7%;
- A new buffer fluid was developed — a 0.2% aqueous solution of polyacrylamide (PAM), which led to a 20–25% improvement in casing quality.

**Scientific Provisions Submitted for Defense**

1. The interrelation between the results and indicators for assessing the quality of cement slurries;
2. Results of experimental studies on the influence of cement slurry composition on its performance indicators;
3. Methodology for assessing cement slurry quality and the risk of potential consequences due to poor cementing;
4. Development of a buffer fluid to improve wellbore integrity and a high-strength cement slurry to increase cement stone strength and reduce its permeability.

**Connection with Program-Based Scientific Research**

This dissertation has been prepared within the framework of the grant project for young scientists *"Zhas Galym"* (No. AR22687661), implemented with the support of the Ministry of Science and Higher Education of the Republic of Kazakhstan during 2024–2026 (dated June 20, 2024, No. 127/zh-n-5-24-26). The research on improving technological solutions for enhancing well integrity at oil fields in Western Kazakhstan forms part of this project, aligning with the topic of the dissertation. The study of this subject has been ongoing since the beginning of doctoral studies in 2020. During the grant implementation, an analysis of cementing quality at fields in Western Kazakhstan was conducted, the results of which formed the basis of the dissertation.

**Approval and Dissemination of Research Results.** The research results were presented at 5 international and 2 national scientific-practical conferences. The work was presented at the following events:

International scientific-practical conference "Development of Science and Technology in the Exploration of Kazakhstan's Subsoil", dedicated to the 90th anniversary of academician Sh. Yessenov (Aktau, 2017);

International scientific-practical conference "Status and Prospects of Operating Mature Fields" (Aktau, 2019);

XIV International Scientific Nadirov Readings "A Bright Example of Continuity in Scientific Traditions and Professional Dedication", held by S. Utebayev Atyrau Oil and Gas University (Atyrau, February 25, 2022);
International scientific-practical conference Khoshbakht Yusifzadeh Readings: "Petroleum Potential and Geoecological Challenges of the Caspian Region" (Baku, December 2024).

From April 19 to 30, 2021, an online internship was conducted, followed by an in-person internship at the National Academy of Sciences of Azerbaijan (Baku, Republic of Azerbaijan) under the guidance of international scientific advisor, Doctor of Technical Sciences, Professor, and Corresponding Member of NAS of Azerbaijan, G.M.Efendiyev.
The National Academy of Sciences of Azerbaijan (NASA) is the main state research institution and coordinating body for scientific and social science activities in Azerbaijan.

As a result of the internship, a joint article with the international advisor and others was published in the journal Socar Proceedings (No. 4, 2024) titled: "Comprehensive Cementing Quality Assessment and Risk Management System".

Scientific Publications

The main results of the dissertation research are presented in thirteen scientific publications, including:

- Two articles in peer-reviewed scientific journals;
- Seven conference abstracts published in conference proceedings;
- One article indexed in the Scopus database;
- Three articles in journals recommended by the Committee for Quality Assurance in the Sphere of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan (KKCOH MON RK).

At an extended meeting of the *"Petrochemical Engineering"* Department of the Caspian State University of Technology and Engineering named after Sh. Yessenov, the work was presented and discussed under the topic: "Improvement of Drilling Technology to Ensure Enhanced Well Integrity at the Fields of Western Kazakhstan".

---

**Structure and Volume of the Dissertation**

The dissertation comprises 130 pages of typed text and includes an introduction, four chapters, a conclusion, and a list of references containing 96 sources. The work is illustrated with 33 figures.

**Factual Base**

The factual base of the dissertation research is based on:

- Data from the author's own research;
- Published articles and monographs in national and international journals (a total of 96 sources);
- Internal project and field reports related to the dissertation topic.