ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ
«ХАЛЫҚ» ЖҚ

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
ЧФ «Халық»

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF
KAZAKHSTAN
«Halyk» Private Foundation

SERIES

OF GEOLOGY AND TECHNICAL SCIENCES

4 (460)

JULY – AUGUST 2023

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными

возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением, Благотворительный Фонд «Халык»!

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

«ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктеуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *геология, мұнай және газды өңдеудің химиялық технологиялары, мұнай химиясы, металдарды алу және олардың қосындыларының технологиясы.*

Мерзімділігі: жылына 6 рет.

Тиражы: 300 дана.

Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19
http://www.geolog-technical.kz/index.php/en/

Типографияның мекен-жайы: «Аруна» ЖК, Алматы қ., Мұратбаев көш., 75.

«Известия НАН РК. Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, химические технологии переработки нефти и газа, нефтехимия, технологии извлечения металлов и их соеденений.*

Периодичность: 6 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19

http://www.geolog-technical.kz/index.php/en/

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75.

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.
Thematic scope: *geology, chemical technologies for oil and gas processing, petrochemistry, technologies for extracting metals and their connections.*
Periodicity: 6 times a year.
Circulation: 300 copies.
Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19
http://www.geolog-technical.kz/index.php/en/

Address of printing house: ST «Aruna», 75, Muratbayev str, Almaty.

NEWS of the National Academy of Sciences of the Republic of Kazakhstan
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224–5278
Volume 4. Number 460 (2023), 97–108
https://doi.org/10.32014/2023.2518-170X.315

UDK 622.245.422.4

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RESEARCH AND DEVELOPMENT OF CEMENTS WITH DIFFERENTIAL PROPERTIES FOR COMPLETING GAS WELLS

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Abstract. The study of problems arising during well cementing can point out two main problems, which appear before and after well cementing. These are gas infiltration during the waiting on cement (WOC); and violation of annular space tightness under dynamic loads. The later is the consequence of gas breakthrough. Gas permeation is caused by a decrease in pressure in the annulus because of cement slurry structuring, which is evident during the transitional period of cement slurry curing. It should be noted that gas does not penetrate into the borehole if the mortar is in the liquid state, but gas also cannot actively enter after the mortar has turned to stone. Since the temperature in the well bottom hole zone is always higher than at the wellhead, the hardening of the cement slurry proceeds from the bottom up. In this case, the hardening slurry itself provides staged gas transfer from the bottom hole to the wellhead. In this aspect may be of interest the method of well curing, when the cement slurry in the borehole hardens from the top downward. The given analysis of the field material on the fields of the Republic of Kazakhstan has shown that improving the quality of cementing

can be achieved by using cement slurries with differential properties. Instruments and equipment corresponding to API and GOST 1581-96 standards were used for conducting researches. The given results of experimental studies allowed obtaining cement slurries for four portions of cement slurries, consistently pumped into annular space, with setting time of 3 hours 20 minutes. Optimal setting time of the second, third and fourth portions of cement slurry was 5–30, 7–20 and 9–40 hours, respectively. All justified formulations of grouts ensured obtaining of stone meeting the requirements of the standards.

Keywords: wellbore stabilization, cement stone, grouting slurry, fiberglass, reinforcement

Acknowledgements. This work was performed within the AP09058636 project "Development of plugging solutions with differential properties" (Ministry of Science and Higher Education of the Republic of Kazakhstan is the source of financing).

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ГАЗ ҰҢҒЫМАЛАРЫН АЯҚТАУ КЕЗІНДЕ ДИФФЕРЕНЦИАЛДЫ ҚАСИЕТТЕРІ БАР ЦЕМЕНТТЕРДІ ЗЕРТТЕУ ЖӘНЕ ӘЗІРЛЕУ

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Аннотация. Ұңғымаларды бекіту кезінде туындайтын мәселелерді зерттеу Ұңғымаларды цементтеуге дейін және одан кейін пайда болатын екі негізгі мәселені атап өтуге болады. Бұл цементтің қатуы кезінде газдың енуі және динамикалық жүктемелер кезінде құбыр кеңістігінің тығыздығының бұзылуы. Соңғысы-газдың жарылуының салдары. Газдың енуі цемент ерітіндісінің құрылымына байланысты құбыр кеңістігіндегі қысымның төмендеуіне байланысты, ол цемент ерітіндісінің қатаюының өтпелі кезеңінде көрінеді. Айта кету керек, егер ерітінді сұйық күйде болса, газ ұңғымаға енбейді, бірақ ерітінді тасқа айналғаннан кейін де газ

белсенді түрде ене алмайды. Ұңғыманың төменгі бөлігінде температура әрдайым аузына қарағанда жоғары болғандықтан, цемент ерітіндісін қатайту процесі төменнен жоғарыға қарай жүреді. Бұл жағдайда қатайтатын ерітіндінің өзі газдың кенжардан аузына кезең-кезеңімен өтуін қамтамасыз етеді. Осыған байланысты Ұңғымаларды бекіту әдісі қызығушылық тудыруы мүмкін, онда ұңғымадағы цемент ерітіндісі "жоғарыдан төменге"қатаяды. Қазақстан Республикасының кен орындары бойынша кәсіпшілік материалға келтірілген талдау цементтеу сапасын арттыруға дифференциалдық қасиеттері бар тампонаждық ерітінділерді қолдану арқылы қол жеткізуге болатындығын көрсетті. Зерттеу жүргізу үшін API және МЕСТ 1581-96 стандарттарына сәйкес келетін аспаптар мен жабдықтар пайдаланылды. Эксперименттік зерттеулердің жоғарыда келтірілген нәтижелері құбырлы кеңістікке дәйекті түрде құйылған цемент ерітінділерінің төрт порциясы үшін тампонаж ерітінділерін алуға мүмкіндік берді, қалыңдау уақыты 3 сағат 20 мин.цемент ерітіндісінің екінші, үшінші және төртінші порцияларының оңтайлы қалыңдау уақыты сәйкесінше 5–30, 7–20 және 9–40 сағатты құрады. Ерітінділердің барлық негізделген формулалары стандарттардың талаптарына сәйкес келетін тасты алуды қамтамасыз етті.

Түйін сөздер: Ұңғымаларды бекіту, цемент тас, тампонаж ерітіндісі, талшықты талшық, арматура

Алғыс және қаржыландыру. Бұл жұмыс AP09058636 «Дифференциалды қасиеттері бар тығындау ерітінділерін әзірлеу» жобасы аясында орындалды (Қаржыландыру көзі ҚР Ғылым және жоғары білім министрлігі болып табылады).

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ИССЛЕДОВАНИЕ И РАЗРАБОТКА ЦЕМЕНТОВ С ДИФФЕРЕНЦИАЛЬНЫМИ СВОЙСТВАМИ ПРИ ЗАКАНЧИВАНИИ ГАЗОВЫХ СКВАЖИН

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Аннотация. Изучение возникающих проблем при креплении скважин можно отметить две основные проблемы, которые проявляются до и после цементирования скважин. Это проникновение газа во время ОЗЦ и нарушение герметичности затрубного пространства при динамических нагрузках. Последнее является последствием газового прорыва. Проникновение газа обусловлено снижением давления в затрубном пространстве из-за структурирования цементного раствора, которое проявляется в переходный период твердения цементного раствора. Следует отметить, что газ не проникает в скважину, если раствор находится в жидком состоянии, но газ также не может активно поступать после того, как раствор превратится в камень. Поскольку в призабойной зоне скважины температура всегда выше, чем на устье, то и процесс твердения цементного раствора идет снизу вверх. При этом твердеющий раствор сам обеспечивает поэтапный перенос газа от забоя к устью. В этом плане может представлять интерес метод крепления скважин, при котором цементный раствор в скважине твердеет «сверху вниз». Приведенный анализ промыслового материала по месторождениям Республики Казахстан показал, что повышение качества цементирования можно достичь применением тампонажных растворов с дифференциальными свойствами. Для проведения исследований использованы приборы и оборудование, соответствующее стандартам API и ГОСТ 1581-96. Приведенные результаты экспериментальных исследований позволили получить тампонажные растворы для четырех порций цементных растворов, последовательно закачиваемых в затрубное пространство, со сроками загустевания 3 часа 20 мин оптимальное время загустевания второй, третьей и четвертой порций цементного раствора составило 5–30, 7–20 и 9–40 часов соответственно. Все обоснованные рецептуры растворов обеспечивали получение камня, соответствующего требованиям стандартов.

Ключевые слова: крепление скважин, цементный камень, тампонажный раствор, волокнистое волокно, арматура

Благодарность и финансирование. Работа выполнена в рамках проекта AP09058636 «Разработка тампонажных растворов с дифференциальными свойствами» (Источником финансирования является Министерство науки и высшего образования РК)

Introduction

The main consequences and problems arising from poor-quality primary cementing are contamination of the productive zone, hydrocarbon production loss and efficiency of applied methods to increase well productivity, as well as migration of gas and fluids in the borehole space.

While studying the mechanism of gas penetration during WOC, many scientists have identified and described the causes (Alfakih et al., 2022; Agzamov et al., 2018; Gowida et al., 2018) the authors have presented the reasons, starting from filtrate penetration deep into the productive formation to the occurrence of underbalance, and respectively

gas penetration into the borehole. Nevertheless, the reasons, causing fluids development, presented by the authors of (Gowida et al., 2018) are not fully presented. In our opinion, if we consider all the reasons causing the process of gas breakthrough, it is necessary to take into account the fact that during drilling to avoid contamination of the productive zone and other problems, drilling mud with water loss of 3–6 cm^3 is used. In addition, during cementing in order to avoid problems that may arise due to high water yield specialists recommend to use grouting mortar with water yield of 50 cm3 /30 min. This problem may be intensifying in the case of fractured reservoir (Turgazinov et al., 2022). All this leads to reduction of radius of conditional blocking (impermeable) zone.

It is also necessary to consider gas breakthrough and gas migration separately. After formation gas breakthrough into the well during WOC by changing differential pressure, gas migration can go through several possible channels (Melo et al., 2019; Drecq, 1989). The first one is a cement slurry or permeable cement stone, and in order to reduce gas migration through this channel it is important to control the density and water loss of the cement slurry. The second is the contact zones of the cement stone, reducing the probability of gas migration through this channel can be minimized by using expanding cements.

The driving force for gas migration into the well and its subsequent movement to the wellhead is the difference between the formation and hydrostatic pressure in the annular space of the well. At the stage of cement slurry solidification it begins to be structured and "hang" on the walls of the well, reducing pressure on the formation, whereby this pressure becomes lower than formation pressure, and formation fluid (oil or gas) begins to flow from the formation into the well, leading to oil and gas seizures. The most dangerous is the transitional period of cement slurry solidification, when its structure transitions from coagulation to crystallization, and the reduction of hydrostatic pressure on the formation occurs most intensively. It should be noted that gas does not penetrate into the well if the slurry is in the liquid state, but gas also cannot actively enter after the slurry has turned to stone (Agzamov et al., 2018; Agzamov et al., 2011).

Therefore, by purposefully managing the kinetics of structure formation for cement slurries, it is possible to maintain the necessary pressure on the formation for a long time, preventing the invasion of reservoir fluid into the cement slurry, and then ensuring rapid transition of solution into the stone "close" the access of fluid into the borehole.

Analysis of field material. The reasons of gas migration through the cured cement stone are often channels and cracks in the stone, caused by low sedimentation stability of the mortar and low impact resistance of the resulting stone, leading to the formation of cracks in it during technological operations carried out in the borehole. Application of reinforcing additives at production string cementing, especially in the interval of productive part of reservoir, increases impact resistance of produced cement (Alfakih et al., 2022). Consequently, application of modifying reinforcing additives in the composition of cements will allow excluding the above drawbacks of plugging materials.

Gershtansky O.S. states, that in order to reduce negative effect of electric fields and charges on well cementing quality we can use grouting mortars with differential properties, more exactly, mortars with different curing times (Gershtanskij et al., 2014; Orynbayev et al., 2019).

Abdullaev N.Ya. et alias (Abdullaev et al., 2014) agree with him and recommend to use technology of differentiated well cementing for wells construction in Uzen field, where cement slurry has different density.

Relevance of the problems associated with improving the quality of well cementing has always been high, especially during the development of oil and gas fields, which are in the last stage, such as in Kazakhstan.

In the fields of the Republic of Kazakhstan there are problems associated with poor-quality performance of primary cementing, accompanied by gas leakage during WOC, gas migration and with inter-casing pressures. In particular, 4 exploration wells were drilled in Shogyrly-Shomyshty field in 2005 (Arangath et al., 2009), in which various problems arose in the process of cementing, including gas leakage.

The authors of (Arangath et al., 2009) believe that the use of backpressure technology during WOC or the use of annular packer installed above the gas formation can solve the gas leakage problem. At the same time the authors of (Davis et al., 2015) recommend to use casing packer or swellable packer for fastening conductors and technical strings.

In the gas field Amangeldy in southern Kazakhstan, there are also problems related to the quality of cementing of wells. It should be noted that mining and geological characteristics of the wellbore section in the Amangeldy field are quite difficult in terms of obtaining quality cementing. This is caused by many factors: the presence of a thick It is determined by many factors: presence of salt-bearing section, gas-bearing sediments, differently pressured horizons, which complicate the process of drilling and cementing of wells. The results of cementing quality assessment according to acoustic cementometry (ACS) are shown in Fig. 1. In 2004–2007 casing strings were cemented in 13 wells of the field. Cementing was carried out with cement brands PCT-I-50 and PCT-I-100 with the addition of water-reducing agent WCCP-402, expanding additive SIGB, retarder of setting time NTP. For cementing of salt-containing deposits the mixing fluid contained NaCl (Agzamov et al., 2018).

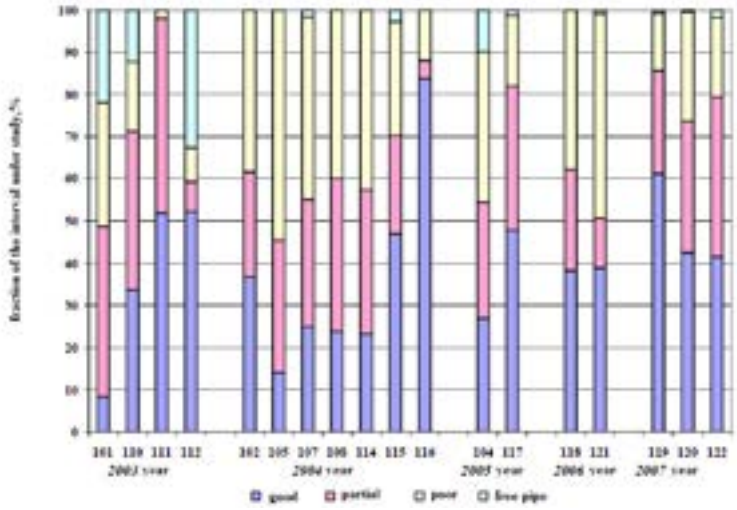

Fig. 1 The contact pattern of the cement stone with the production string of the Amangeldy gas field

The diagrams show that application of fluid loss additiveVPK-402, which increases water retention of fresh mortar, improved the quality of well cementing properly.

Another example is the North Buzachi field, characterized by highly porous and highly permeable reservoirs located at a depth of only 400–500 meters (Nie zhen et. al., 2010), (Mohammad et al., 17). Wells drilled in this field also had problems in the form of water-gas seepage, loss of circulation; extended WOC time due to low temperatures.

(Nie zhen et.al., 2010) stated that gas blocker G60S and expanding additive BXP-1S were effective for North Buzachi field.

The analysis of the production material, as well as the literature review of the Russian fields, concerning the problems of low quality cementing, especially the problems of gas leakages, gas migration ways and inter-casing pressures showed that the main ways of solving these problems are concentrated on the following

— providing tight contact of grouting stone with casing pipe and at the same time with rock by means of expanding additives

— Using additives, which block gas breakthrough into the well during WOC.

Besides, gas leakages can also occur because of cement fracture or cracking in annular space, caused by inner pressures in the casing and cyclic loads arising during completion, development and production phases of hydrocarbons. Their consequence is cracks in the cement stone (McDaniel et al., 2014).

In accordance with the field data, a sharp deterioration of the quality factor of cementing casing after carrying out geological and technological measures may be noted.

Literature review and analysis of production material showed that dispersion-reinforced materials are more effective for increasing impact resistance of plugging stone.

Initially, organic fibers were used to improve the quality of well completions, which increased the mechanical properties of cement slurry. In particular, the authors of work (Agzamov., 2013) showed that strength of cement stone with addition of 0.55 % of fibers increased by 10 %, and further with increase of fiber amount up to 1.25 % the strength of cement stone increased by 40 %.

At the beginning of cement slurry solidification processes are actively developing in it, resulting in vacuum formation inside the solidifying system and contributing to active "suction" of gas. As the temperature in the bottomhole zone is always higher than at the wellhead, the process of cement slurry curing is going from the bottom upwards. In this case the hardening mortar itself provides staged gas transfer from the bottomhole to the wellhead. In this regard may be of interest the method of well curing, when the cement slurry in the borehole hardens "from top to bottom".

We suppose that in order to increase cementing quality by preventing behind-the-hole gas seepage, it is reasonable to use expanding dispersion-reinforced plugging materials with differential setting times of mortars. The latter suggests that curing of plugging solution in the annular space should take place from top to bottom (Kabdushev, 2023). In this case the upper, earlier hardened portion of the cement slurry will "lock" the annular space, blocking gas inflow from formation into the hardening cement slurry. The development of that cementing material was the goal of this study.

Research methods and materials used

The devices and equipment corresponding to API standards and GOST 1581–96 were used for the studies. Studies were carried out at temperatures of 22 and 50°C. Water-cement ratio of solutions was 0.44 and 0.7, which ensured the density of the obtained solutions of 1880 and 1650 kg/m^3.

To study technological properties of plugging solutions, more precisely density, flowability, filtration index, pump ability and water separation, the following instruments were used:

— Lever scales for determining the density of cement mortars.

— Instrument for determining the flow ability of cement slurry - AzSRPI cone.

— Apparatus for determination of cement slurry flow ability - BM-6.

— Consistency meter — OFITE-60 consist meter in accordance with American Petroleum Institute (API) standards.

— Cylinders for determination of cement slurry water release according to American Petroleum Institute (API) standard.

For evaluation of strength properties of plugging material we used the following equipment

— MATEST E160 N testing machine for determination of flexural and compressive strength in accordance with API standard.

— Ofite Model 90 Cement Permeameter according to API standard.

— Instrument for determination of linear expansion of cement during curing -Organic steel ring mold

— cooper for determination of impact strength of grouting stone.

For the tests there were used:

— Portland cement PCT-I-G-SS-1 and PCT II-50;

— Polypropylene fibers;

— Expanding additive RD-CT produced by OOO Cement Technologies;

— Fluid-loss additive and viscosities -Well fix;

— Retarder of cement mortar setting time - NTP;

— Gas pedals of setting time of $CaCl_2$ and NaCl solutions.

In accordance with the set task, the purpose of the experimental studies was to develop formulations of cementing slurries with different setting times:

— The first portion placed in the upper zone of the cemented interval was to have the shortest pumping time of 3 hours and 20 minutes;

— The second portion, placed in the middle zone of the cemented interval, was to have pumping time of 5 hours and 30 minutes;

—The third portion, placed in the upper zone of the cemented interval, should have pumping time of 7 hours and 30 minutes;

—The fourth portion, to be placed in the upper zone of cemented interval, should have the longest pumping time of 9 hours and 30 minutes.

According to well placement temperature of cement slurry portions, tests were conducted at temperatures of 22 and 50°C.

At the same time, the strength of the resulting cement stone from all portions of cement slurries should not be below the requirements of GOST 1581-96.

Results

Development of formulation of cement slurry for the first portion.

The lightened mortar contained expanding additive RD-CT - in quantities of 0%; 2%; 5%; 10%. $CaCl_2$ from 1 to 4 % was used to control the setting time. The concentrations of polypropylene reinforcing additive investigated were 0 %; 0.1 %; 0.25 %; 0.5 %.

Water-cement ratio — 0.7. Wellfix was used as a structural agent.

After several series of experiments with the above concentrations of ingredients the optimized composition of plugging material was represented by Portland cement PTC-I-G-CS-1, expanding additive RD-CT – 5 %; CaCl2-1 %; fiber PP-0.5 %; water-reducing agent Wellfix - 0.2 % The obtained mortar had the following indicators

— Density - 1640 kg/m^3;

— Flow ability - 25 cm;

— Water loss - 58 cm^3/30min;

— pump ability at T=22°C was 4 hr 30 min, at T=50°C - 3 hr 30 min;

— Water separation - 7 ml;

Cement stone, obtained from this mortar, had the following indicators:

Flexural / compressive strength at T=22^{o}C

— At the age of 2 days -1.9/5.7 MPa;

— At the age of 7 days - 7.3/21.1 MPa.

Flexural/compressive strength at T=50°C

— At the age of 2 days - 4.1/10.0 MPa;

— At the age of 7 days - 20.1/30.2 MPa.

Fracture toughness at T=22^{o}C at the age of 2/7 days was 0.35/0.65 J/cm^3.

The impact fracture toughness at T=50^{o}C at the age of 2/7 days was 0.61/0.66 J/$^{cm3.}$

The permeability of the cement stone at T=22^{o}C at the age of 2/7 days was 56.2/2.9 mD.

The permeability of the cement stone at T=50^{o}C at the age of 2/7 days was 41.1/2.1 mD.

Development of formulation of cement slurry for the second portion.

The lightened mortar contained expanding additive RD-CT in quantities of 2%; 5%; 10%. To regulate setting time NaCl was used at concentrations of 1 %; 3 %. Investigated concentrations of reinforcing additive — polypropylene fiber – 0 %; 0.1 %; 0.25 %; 0.5 %. Water-cement ratio — 0,7. Well fix was used as a structural agent.

The conducted experiments with specified concentrations of ingredients have allowed to optimize the composition of plugging material, represented by Portland cement PTC-I-G-CS-1, expanding additive RD-CT – 2 %; NaCl – 3 %; fiber PP-0,1 %; water-reducing agent Wellfix - 0.2 % The obtained mortar had the following indicators

— Density – 1650 kg/m^3;

— Flow ability – 27 cm;

— Water loss – 150 cm^3/30min;

— pump ability at T=22°C was 5 hr 45 min, at T=50°C - 5 hr 20 min;

— Water separation – 9 ml;

Cement stone, obtained from this mortar, had the following indicators:

Flexural / compressive strength at T=22°C

— At the age of 2 days – 2.2/6.7MPa;

— At the age of 7 days – 6.5/20.2 MPa.

Fracture toughness at T=22°C at the age of 2/7 days was 0.13/0.17 J/cm^3.

The impact fracture toughness at T=50°C at the age of 2/7 days was 0.18/0.20 J/cm3.

The permeability of the cement stone at T=22°C at the age of 2/7 days was 96.2/3.9 mD.

The permeability of the cement stone at T=50°C at the age of 2/7 days was 59.1/3.1 mD.

Development of formulation of cement slurry for the third portion.

Experimental studies were conducted with plugging materials containing expanding additive RD-CT – 2 %; 5 %; 10 %. For regulation of setting time NTP - 0,01% was used; Polypropylene reinforcing additive concentrations – 0 %; 0,1 %; 0,25 %; 0,5 % were investigated. Water-cement ratio — 0,44. Well fix was used as a structural agent.

Optimized composition of plugging material was represented by Portland cement PCT-I-G-CC-1, expanding additive RD-CT – 5 %; NTP -0.01 %; fiber PP-0.25 %; water-reducing agent Well fix - 0.2 % The obtained mortar had the following indicators

— Density — 1840 kg/m^3;

— Flow ability — 24 cm;

— Water loss — 41 cm^3/30min;

— pump ability at T=22°C was 8 hour 35 min, at T=50°C — 7 hour 20 min;

— Water separation — 0 ml;

Development of formulation of cement slurry for the fourth portion.

Experimental tests were performed with plugging materials containing expanding additive RD-CT – 2 %; 5 %; 10%. NTP — 0.01 % was used for regulation of setting time; Polypropylene reinforcing additive concentrations – 0 %; 0.1 %; 0.25 %; 0.5 % were investigated. Water-cement ratio - 0,44. Well fix was used as a structural agent.

The optimized composition of plugging material differed from the plugging material of the third portion by the increased concentration of NTP to 0.03%.

The obtained solution had the following indicators:

— Density — 1880 kg/m^3;

— Flow ability — 24 cm;

— Water yield — 40 cm^3/30min;

— pump ability at T=50°C was 9 hr 40 min;

— Water separation — 2 ml;

Cement stone, obtained from this mortar, had the following indicators:

Flexural / compressive strength at T=50°C:

- At the age of 2 days - 25.0 / 37.0 MPa;

- At the age of 7 days - 73.5 / 95.5 MPa.

Fracture toughness at T=50°C at the age of 2/7 days was 0.76/0.91 J/cm^3.

The permeability of the cement stone at T=50°C at the age of 2/7 days was 63.2/3.2 mD.

Conclusions

1. In all experimental studies the addition of fiber has a positive effect on strength properties and impact resistance of cement stone.

2. It was experimentally established that the optimal concentration when using polypropylene fibers for cement slurries with expanding additives is 0.25 % with a length of 3 mm.

3. According to the task, four formulations of cementing slurries with different setting times have been developed:

— For the first portion of the experiments the following formulation of cement slurry with W/C=0.7 was proposed: RD-CT-5 %; $CaCl^2$-1%; fibre PP -0.5 %; Wellfix-0.2 % which has a pumping time of 3 h 30 min.

— For the second portion there is a prescription of grouting mortar with WV/C 0.7; RD-CT -2%; $NaCl^2$-1 %; fibre PP -0.25, which has pumping ability of 5 hours 30 minutes. However, this formulation is suitable only by pumpability criterion and there is a need to optimize water-holding properties of plugging solution.

— For the third portion, a recipe for grouting mortar with W/C=0.44; RD-CT – 5 %; NTP - 0.0 1%; fibre PP - 0.25 %; Wellfix -0.2 %, which has pumping ability of 7 h 20 min.

— For the fourth portion of experiments the following formulation with W/C=0.44: RD-CT -5 %; NTP - 0.03%; fibre PP -0.25; which has a pumping capacity of 9 h 40 min.

Hereby, new formulations of expanding cementing materials with reinforcing additives with differential setting times of the mortars have been obtained experimentally.

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ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Подписано в печать 16.08.2023.
Формат 70x90 1/16. Бумага офсетная. Печать – ризограф.
20,0 п.л. Тираж 300. Заказ 4.

Национальная академия наук РК
050010, Алматы, ул. Шевченко, 28, т. 272-13-19