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Satbayev University

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STYDING THE EFFECT OF REINFORCEMENT ON THE PROPERTIES OF PLUGGING MATERIALS WITH EXPANDING ADDITIVES

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Abstract. Ensuring the tightness of the insulation and durability of the cement stone depends on many factors that occur at all stages of cementing the operational column. If one of them is the penetration of gas during cementing or after the delivery of cement mortar into the annular space, then another factor is in-well work that creates dynamic loads on the cement stone and violates the tightness of the annular space insulation. These factors can be the cause of many problems that arise during the operation of the well. Therefore, improving the quality of well anchoring taking into account these factors, especially in the productive formation zone, is always relevant. Since the initiation of gas penetration into the cement mortar can manifest itself when moving upwards in the annular space and during its hardening, it becomes necessary to use expanding and reinforcing additives in the development of grouting material formulations. The article offers for consideration the results of a study conducted to assess the effect of reinforcement on the properties of grouting materials with expanding additives, as well as the role of other modifying additives. They make it possible to increase the deformation stability, prevent the destruction of cement stone when exposed to shock loads and minimize the processes of gas entering the cement mortar (stone). Instruments and equipment conforming to API and GOST 1581–96 standards were used for the research. The results of experimental studies made it possible to obtain grouting solutions with expanding and reinforcing additives at a concentration of 0.25 %, providing the necessary deformation stability of the grouting stone.
Keywords: well fastening, cement stone, grouting mortar, fiber fiber, reinforcement

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ҰЛҒАЙТУШЫ ҚОСПАЛАРЫ БАР ТЫҒЫНДАУ МАТЕРИАЛДАРЫНЫҢ ҚАСИЕТТЕРІНЕ ШЫРМАЛАУДЫҢ ӘСЕРІН ЗЕРТТЕУ

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Аннотация. Оқшаулаудың герметикалығын және цемент тастың беріктігін қамтамасыз ету жұмыс бағанының цементтелуінің барлық кезеңдерінде болатын көптеген факторларға байланысты. Егер олардың бірі цементтеу кезінде немесе цемент ерітіндісін сақина кеңістігіне жеткізгеннен кейін газдың енуі болса, онда тағы бір фактор-бұл цемент тасына динамикалық жүктемелер тудыратын және құбыр кеңістігінің оқшаулауының тығыздығын бұзатын ұңғыма жұмыстары. Бұл факторлар ұңғыманы пайдалану кезінде туындайтын көптеген мәселелердің себебі болуы мүмкін. Сондықтан, осы факторларды ескере отырып, Ұңғымаларды бекіту сапасын арттыру, әсіресе өнімді қабат аймағында әрқашан өзекті болып табылады. Цемент ерітіндісіне газдың енуінің басталуы сақина кеңістігінде жоғары қарай жылжу кезінде пайда болуы мүмкін және ол қатайған кезде тампонаждық материалдың рецептурасын жасау кезінде кеңейтетін және күшейтетін қоспаларды қолдану қажет болады. Мақалада кеңейту қоспалары бар тампон материалдарының қасиеттеріне арматураның әсерін және басқа модификациялаушы қоспалардың рөлін бағалау бойынша жүргізілген зерттеу нәтижелері қарастырылады. Олар деформацияға төзімділікті арттыруға, соққы жүктемелеріне ұшыраған кезде цемент тасының бұзылуын болдырмауға және цемент ерітіндісіне (тасқа) газ ағынын азайтуға мүмкіндік береді. Зерттеу жүргізу үшін API және ГОСТ 1581–96 стандарттарына сәйкес келетін аспаптар мен жабдықтар пайдаланылды. Эксперименттік зерттеулердің жоғарыда келтірілген нәтижелері 0,25 % концентрацияда кеңейтетін және күшейтетін қоспалары бар тампондық ерітінділерді алуға мүмкіндік берді, бұл тампондық тастың қажетті деформациялық тұрақтылығын қамтамасыз етеді.

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

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ИЗУЧЕНИЕ ВЛИЯНИЯ АРМИРОВАНИЯ НА СВОЙСТВА ТРУБОЧНЫХ МАТЕРИАЛОВ С РАСШИРЯЮЩИМИ ДОБАВКАМИ

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Аннотация. Обеспечение герметичности изоляции и долговечности цементного камня зависит от многих факторов, которые имеет место во всех этапах цементирования эксплуатационной колоны. Если одним из них является проникновение газа во время цементирования или после доставки цементного раствора в кольцевое пространство, то другим фактором являются внутри скважинные работы, которые создают динамические нагрузки на цементный камень и нарушают герметичность изоляции затрубного пространства. Эти факторы могут быть причиной многих проблем, возникающих при эксплуатации скважины. Поэтому повышение качества крепления скважин с учетом данных факторов, особенно в зоне продуктивного пласта всегда является актуальной. Так как инициирование проникновения газа в цементный раствор может проявляются при движении вверх в кольцевом пространстве и при его твердении возникает необходимость применения расширяющих и армирующих добавок при разработке рецептур тампонажного материала. В статье к рассмотрению предлагается результаты проведенных исследований по оценке влияния армирования на свойства тампонажных материалов с расширяющими добавками, а роль других модифицирующих добавок. Они позволяют повысить деформационную устойчивость, предотвратить разрушения цементного камня при воздействии ударных нагрузок и минимизировать процессы поступления газа внутрь цементного раствора (камня). Для проведения исследований использованы приборы и оборудование, соответствующее стандартам API и ГОСТ 1581–96. Приведенные результаты экспериментальных исследований позволили получить тампонажные растворы с расширяющими и армирующими добавками при концентрации 0,25 %, обеспечивающие необходимую деформационную устойчивость тампонажного камня.

Ключевые слова*:* крепление скважин, цементный камень, тампонажный раствор, фиброволокно, армирование

Introduction

Discovery of new deposits and growth in the volume of prospecting and exploration work in various regions of the UIS countries. For example, in recent years, new fields with large reserves have been discovered in Kazakhstan, such as the Klimene field, which is being developed by Tethys Petroleum, and the Khalela Uzbekgaliyeva field (Kaz Energy. The national energy report. P. 232 (2021)). This allows us to conclude about the prospects for production drilling, and, consequently, the growth in the volume of related work and services. It is known that fixing is one of the most important and most difficult stages in the entire cycle of well construction. At the same time, the wellbore is always in difficult thermobaric conditions, therefore, the technology of well casing provides the only possible, today, way to create a well casing by filling the annulus with cement slurry, which after a while should form a strong impermeable stone. This operation requires special control, because its further fate depends on the quality of well casing.

It has been established that the majority of oil and gas wells in the world have interest ratal flows of varying intensity or leakage of the support (Kireev, 2015). There is a need to carry out work to eliminate the leakage of the cement ring or casing, which, in addition to material costs and time, reduces the further productivity of the well by 10–15 % due to their killing during repair work (Shilov, 2013).

Therefore, high quality and the correct choice of plugging materials, the correct implementation of all technological operations can prevent a number of problems and increase the life of the well. In addition to cementing techniques and technologies, a very promising area is the development of modified cement compositions aimed at solving a number of problems that cannot be excluded even with full compliance with all regulations and the use of the latest technology (Gregatti et al., 2015).

One of the main disadvantages of cementing materials is the low resistance of the resulting stone to impact loads, as a result of which cracks form in it during work carried out inside the casing string. Such works include pressure testing, perforation, cement cup drilling, well deepening and hydraulic fracturing. The appearance of cracks in the cement sheath leads to subsequent complications associated with leakage of the annulus, such as cross-flows, annular circulation, annular pressures, further and deeper destruction of the cement stone.

The strongest stresses in the well lining occur at the stage of the secondary opening of the reservoir. Despite the presence of gentle perforation methods that allow you to carefully open the reservoir and avoid high loads on the casing, the most widely used perforation method is cumulative. According to (Gregatti et al., 2015), dynamic loads on the casing string and cement lining increase up to 300 MPa, and the diameter of the string itself can increase by 15 mm (Agzamov, 2011). Such stresses certainly cause cracks in the cement stone and are capable of destroying it already in the early stages. It was shown in (Samsykin, 2007) that the propagation zone of stresses dangerous for the cement stone can spread up to 10 m above and below the perforation interval, and the cracks formed in the cement stone lead to watering of the well production already at the stage of development.

Drilling out the cement cup, casing shoe, as well as further deepening of the well negatively affects the integrity of the cement stone and is also one of the reasons for the leakage of the support even before the completion of the well construction. The analysis of field materials (Tikhonov, 2013) showed that during the drilling (deepening) of the well after cementing, it causes a deterioration in the contact between the cement stone and the casing string due to high vibrations and beats of the drill string against the inner walls of the well casing string.

Today, a significant part of additionally produced oil becomes available due to hydraulic fracturing, and the number of wells using this technology is growing every year. The process of hydraulic fracturing also poses a serious threat to the cement ring, since in addition to a significant dynamic load, there is also a large static load that lasts for a long time, about 1.5–2 hours (Agzamov, 2017). The work (Tikhonov, 2013) shows the field statistics of the causes of behind-the-casing fluid circulation (FCC) in some fields, from which it follows that, on average, more than 70 % of wells have leakage due to perforation and hydraulic fracturing processes, which indicates insufficient strength of the cement stone for carrying out this operation (Orynbayev et al., 2019).

Often, the strength of the cement stone does not correspond to the actual loads that occur during various operations in the well, since when designing the composition of backfill materials, a number of factors that have a serious impact on the integrity of the cement stone are usually not taken into account. The paper (Samsykin, 2007) compares the strength of the cement stone with the loads that occur during certain operations at different temperatures, which were obtained by calculation. From the presented work it follows that the cement stone in most cases is not able to maintain tightness during work in which the main loads are dynamic (Agzamov, 2017).

These data indicate the need to take into account the strength of the stone during technological operations in a cased well, and the need to take into account these factors when developing the formulations of cement compositions, paying special attention not only to strength, but also to the resistance of the stone to dynamic loads (Orynbayev et al., 2019).

Currently, for cement stone, indicators of compressive and bending strength are regulated. At the same time, a number of researchers consider it necessary to introduce requirements for the elastic properties of cement stone and propose to introduce indicators of cement stone properties necessary to assess its elastic properties, which are important during operations leading to the occurrence of shock loads (Bu et al., 2020).

In this regard, the issue of developing cementing materials with sufficient resistance to dynamic loads is relevant. Among the modifying additives that increase the impact resistance of cement stone, we can distinguish: 1) polymers, which, when mixed with cement, reduce its strength, but increase plasticity; 2) small amounts of microspheres, which can act as dampers or absorbers of stresses that occur in the stone and prevent destruction; 3) fiber — a fibrous material (basalt, glass fiber, asbestos), when using which part of the external load is perceived by the cement stone, and part is perceived by the reinforcing additive, and the more randomly the fiber is distributed in the volume, the better the stone works for any type of loading, in including impact loads (Erofeev et al., 2011). The fiber is classified according to the value of Young's modulus E, according to which low-modulus and high-modulus fibers are distinguished. The first group includes fibers with an elastic modulus of up to 250 GPa (basalt, asbestos, etc.), as well as fibrous materials with an elastic modulus of up to 700 GPa (carbon fibers, etc.).

The high modulus fiber makes it possible to achieve higher strength values of the cement stone in relation to the stone from traditional cements.

Low-modulus fiber does not allow achieving high strength values, but it is able to reduce stone shrinkage during hardening, and, therefore, eliminate the appearance of cracks, increase deformation resistance and provide a higher water-holding capacity of the mortar (Erofeev et al., 2016).

Fibre-reinforced cement has a different failure mechanism than unreinforced cement. First, a microcrack appears in the cement stone, then it cracks, and the load of the collapsing zone is perceived by the fiber, some fibers are torn, then the load is taken by the remaining fibers located in the fracture zone, after which the continuity of the components is broken, and the bearing capacity of the fibers is lost (Bu et al., 2020). When a reinforced stone is destroyed, two options are possible — fiber rupture or its pulling out of the matrix (Stel'makh et al., 2021). Obviously, the greatest effect from the use of fiber is achieved in the first type of destruction, while the degree of adhesion of the fiber to cement, as well as the depth of its anchoring, are very important.

The research results given in works (Stel'makh et al., 2021) show that the amount of fiber in plugging materials should be (0.3–0.5) %, with a fiber length of (3–5) mm. This does not exclude the use of fibers with different characteristics and at higher concentrations, but field experience has shown that with a larger number and longer lengths of fibers there is a problem with the preparation of cement slurry due to clogging of the cement supply holes. Combining fibers of different origin is effective (Quercia et al., 2016). In 2015, the authors of (Abtahi et al., 2010) noted the effectiveness of polypropylene fiber.

According to (Agzamov et al., 2011), the modification of cements with fiber concentration up to 2 % can provide an increase in bending strength by (15–35) %, in compression – (8–12) %, in tension – (20–100) %. The value of specific impact strength can increase from 30 to 75 %. Longitudinal and transverse compressive deformation at failure increases by 50–70 %. The addition of fiber in recommended amounts has the least effect on the filtration properties of cement mixtures, while sedimentation stability increases by 30–50%, which helps prevent possible manifestations and collapses during cementing (Erofeev et al., 2016).

In (Quercia et al., 2016), 6 mm basalt and polypropylene fibers were used to reinforce expanding lightweight cement. When using basalt fiber, it was possible to increase the compressive and bending strength by 19 and 24 %, respectively, polypropylene fiber was not suitable for increasing strength characteristics. Impact endurance increased almost 3 times when using basalt fiber and 2 times when using polypropylene fibers. These studies also confirmed a positive effect on the change in water loss and a slight change in filtration properties within acceptable limits (Abtahi et al., 2010).

In addition to these types of fibers, asbestos can be used to reinforce grouting materials. Asbestos fiber in the process of cement hardening forms a common structure with stone due to its composition, which contains compounds similar in composition to cement stone (Galishnikova et al., 2021). However, in the world, asbestos is treated with caution, despite its widespread use in construction.

To combat losses in permeable formations during well drilling, various types of fibers are used, for example, cellulose fibers, cotton fiber and other fillers, which play the role of bridging additives in the intervals of absorbing formations. These additives can also be used in plugging materials, however, the effect for plugging materials is less than with the addition of the previously described types of fibers (Agzamov, 2013).

Schlumberger has its own development of an anti-absorption builder, which includes fiber in its composition. These are the so-called “CemNET” and “CemNET+” technologies, which can be used both as part of the cement mixture and as part of drilling fluids, since the fibrous material is able to pass through bit nozzles with a size of 6.4 mm. Additives can be used with any liquids, as they are inert and have little effect on the properties of the cement mixture. However, the fibers should only be used for injection into the loss interval, because an impermeable network is formed in the loss zone, which isolates the loss channels. This technology proved to be successful in the Deepwater Malaysia Malikai field, when the drilling crew faced catastrophic losses and loss of fluid circulation, it became clear that cementing the drilled interval would be a formidable task. Schlumberger representatives suggested using the development of "CemNETfiber technology". This technology gave positive results, the fiber fibers plugged the absorption channels with the formation of an impermeable grid, the well was cemented according to the plan with the least loss of cement slurry, which was necessary to prevent absorption. This saved time and avoided costly repairs, below is the cementing schedule for this interval (Figure 1).

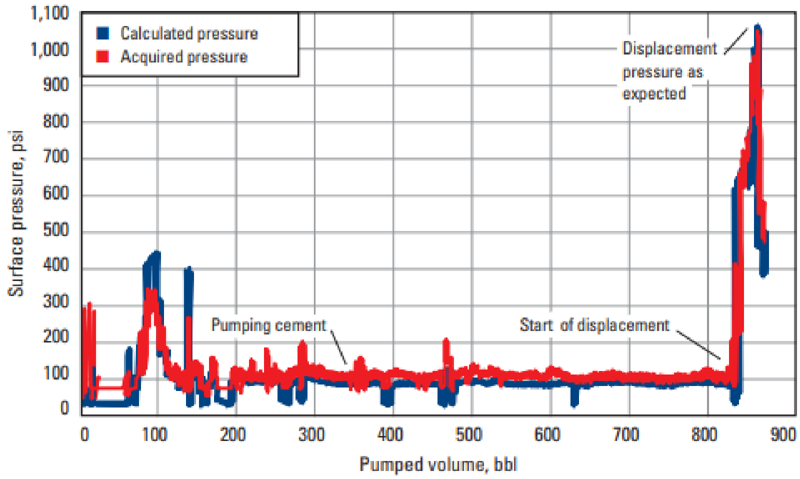


Figure 1-Schedule of cementing a wellin the Deepwater Malaysia Malikai fieldusing CemNET fiber-modified cement

As can be seen from the graph, the actual maximum pressure on the aggregates during cementing and the volume injected into the well correspond to the calculated ones, which confirms the effectiveness of the technology, and, consequently, the effectiveness of the fiber as a bridging agent.

Fiber can be very effective when using lightweight expanding cements. The fact is that lightweight cements, as a rule, have a water-cement ratio (W/C) of more than 0.7, which significantly reduces the effectiveness of expanding additives (ED) (Agzamov et al., 2016), which are designed to ensure tight and reliable contact of the cement stone with the casing string.

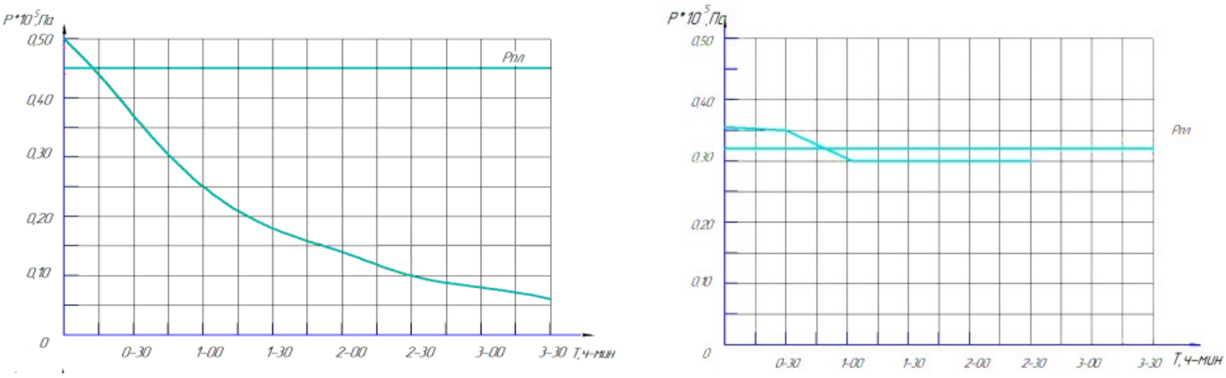
The fact is that during the hardening of cement, contraction inevitably arises (Agzamov et al., 2016), leading to shrinkage of the stone during hardening. At the same time, as a result of the formation of a cement gel, the volume of hardening products increases in comparison with the initial volume of cement. These effects have the opposite result, but shrinkage is most often observed, which worsens the quality of contact between the cement stone and the bounding surfaces. That is why the addition of expanding agents is practiced in backfill materials, which, interacting with water, increase in volume and push the cement grains and hardening products apart. In cement slurries with a high water-cement ratio, the hardening products and the expanding additive are at a sufficiently large distance from each other, as a result of which the expanding additive cannot create pressure on the structural frame of the hardening products, leading to their expansion and expansion. The addition of fiber at the early stages of mortar and stone hardening ensures the transfer of the forces of the expanding additive to the cement hardening products, which leads to an increase in the volume of the cement stone (Ahmed et al., 2018).

In practice, it is often necessary to use lightweight cement mixtures in order to prevent the absorption of cement slurry, because ordinary cement slurry creates a sufficiently high hydrostatic pressure, when cementing formations with abnormally low pressure, this can become a serious problem.

The density of the cement slurry can be reduced by lightening additives or by increasing the water-cement ratio, in both cases the quality of the casing string is reduced. Such cements are most susceptible to gas breakthroughs. Mortars with a high water-cement ratio have lower sedimentation stability compared to solutions of normal density, their water loss is much higher, the density of the mixture is distributed unevenly along the wellbore, and through channels appear during the hardening process.

Cement slurries are prone to gas breakthrough in the early stages of hardening, because as the cement hydrates, the hardening products bond with the walls of the well and the casing and the formation of a structure in the hardening cement-water slurry. In this case, the hydrostatic pressure of the solution is not transferred to the bottomhole, and a pressure drop occurs between the reservoir and the well, which causes gas to enter the annulus. According to V.D. Malevansky, more than 50 % of gas shows that turned into open fountains occurred precisely during the waiting period for cement hardening (WSC). An aggravating factor is the high permeability of the cement stone at this stage.

Studies in (Rozhkov, 2020) show that the reinforcing additive, forming a structure in the initial stages, is able to block gas breakthrough. The authors conducted a comparative analysis of a mortar made from conventional lightweight cement with lightweight fiber-modified cement. Studies carried out on a special installation developed at the Ufa State Oil Technical University (USPTU) showed that when using a cement slurry with the addition of fiber, there was no strong decrease in the hydrostatic pressure of the cement slurry column compared to the formation pressure during the WOC, which, after a slight decrease, remained constant during the entire time of the experiment, which cannot be said about the cement slurry without a modifying additive. The results of the study are shown in the form of graphs in Figure 2, clearly illustrating the effectiveness of the addition of fiber, which significantly increases the ability of the cement slurry to prevent gas movement during the hardening process.



Cement without fiber addition (PCT III-vol 5-50, W/C=0.65) Fiber cement (PCT III-vol 5-50, W/C=0.65)

Figure 2-Reduction of hydrostatic pressure on the formation when using solutions from various cements

Works (Samsykin, 2007) also proved the effectiveness of fiber as a gas blocker, even after repeated simulations of further drilling.

The problem is always easier to prevent than to prevent, which is what reinforced grout cement mixtures do, however, it is worth noting the ability of some types of fiber fibers to contain existing cracks and prevent them from growing, destroying the cement stone. For example, in the study of the author (Rozhkov, 2020), it was shown that with the addition of polypropylene fiber, there is no volumetric destruction of the stone, only local chips and cracks are observed.

The effectiveness of the use of fiberglass and asbestos with a concentration of 0.5 % and (0.5–1) %, respectively, has been experimentally proven in terms of overgrowing cracks and preventing gas breakthroughs in the cement stone. Fibre-modified cements exhibited much less discontinuity upon failure, which was not the case for the unadded samples.

An analysis of the works cited above allows us to conclude that the use of reinforcing additives, among other advantages, has a positive effect on the destruction of cement stone, preventing crack propagation. Even if the dynamic loads on the cement stone are severe enough to destroy the reinforced cement, some fibers may prevent further failure of the stone. Referring to the mechanism of destruction of the cement stone modified with fiber (Agzamov, 2016), it is necessary to note the importance of the degree of adhesion of the fiber to the cement matrix and the depth of penetration, because if the fiber has poor adhesion, it will simply be torn out of the cement stone when significant loads are applied, and the technology will not be effective.

The above analysis of the use of dispersed reinforcement of grouting cements shows the prospects of this technological method for obtaining effective grouting systems with differential properties, for their use when fixing wells in various mining and geological conditions.

Materials and methods

For research, instruments and equipment were used that meet the standards of API and GOST 1581–96 and GOST 30353–95. The studies were carried out at temperatures of 22oC.

Devices:

1. To study the effect of fluid loss reducers on the water-retaining and, in particular, sedimentation properties of the cement slurry with a reinforcing additive, the VM-6 device (GOST 1581–96) and glass cylinders were used to determine the cement slurry segregation (API).

2. To evaluate the effect of polypropylene fiber on the rheological properties of cement slurry with an expanding additive, such as plastic viscosity, dynamic shear stress, static shear stress at 10 s. and at 10 minutes (Samsykin, 2007).

3. Studies of the effect of polypropylene additives on the strength properties (in bending and compression) of cement stone with expanding additives were carried out on a MATEST E160 N (API) machine.

4. To study the effect of a reinforcing additive on rheology, atmospheric viscometers were used.

5. To determine the effect of a reinforcing additive on the adhesion of a cement stone containing an expanding additive to metal, samples were cast into special metal molds and a MATEST E160 N(API) machine was used.

6. To assess the deformation resistance of cement stones containing polypropylene fiber and KMD, a pile driver was used (GOST 30353–95)

Used materials and reagents:

KMD – expanding additive produced by Cement Technologies LLC;

CaCl2 – calcium chloride treated with calcium stearate;

NaCl – sodium chloride;

PPV – polypropylene fiber;

FLOSS – fluid loss reducer;

NTF – retarder of hardening of cement mortars;

EXR – 250–fluid loss reducer

Results and discussions

Determination of the influence of a reinforcing additive on the filtration properties of a cement slurry with expanding additives.

The composition of the recipes for research:

Composition 1–W/C 0.7; KMD-5 %; CaCl2-4 %; PPV-0.25 %; Floss-0.3 %

Composition 2–W/C 0.7; KMD-5 %; NaCl-4 %; PPV-0.25 %; Floss-0.3 %

Composition 3–W/C 0.44; KMD-5 %; NTF-0.2 %; PPV-0.25 %; Floss-0.3 %

Composition 4–W/C 0.44; KMD-5 %; NTF-0.1 %; PPV-0.25 %; Floss-0.3 %

Table 1 - Results of measuring the filtration properties of cement slurry

Compound	V/C	Density	Water separation, ml/2 hours, when the cylinder is tilted	Water loss, cm3/30 min
			0 град	
Compound 1	0,7	1.66	9	-
Compound 2	0,7	1.63	50	15
Compound 3	0,44	1.94	0	10
Compound 4	0,44	1.93	0	8.5

Composition № 1 is not suitable for spreadability, it turned out to be a very thick solution. It was proposed to reduce the concentration of fiber and CaCl2. Also, the filtration characteristics of the cement slurry with formulation 2 did not meet API standards. Sodium chloride (NaCl) was replaced by calcium chloride (CaCl2) due to low efficiency. After a number of adjustments, the recipes were changed as follows:

Composition 1–W/C 0.7; KMD-5 %; CaCl2-2.6 %; PPV-0.15 %; Floss-0.5 %

Composition 2–W/C 0.7; KMD-5 %; CaCl2-2.5 %; PPV-0.25 %; Floss-0.3 %

Composition 3–W/C 0.44; KMD-5 %; NTF-0.05 %; PPV-0.25 %; Floss-0.3 %

Composition 4–W/C 0.44; KMD-5 %; NTF-0.09 %; PPV-0.25 %; Floss-0.3 %

Table 2 - The results of measuring the filtration properties of the cement slurry after adjustment

Compound	V/C	Density	Water separation, ml / 2 hours, at an inclinationцилиндра	Water loss, cm3/30 min
			0 град	
Compound 1- fiber 0.15%	0,7	1.650	0	27

Compound 2-fiber 0.25 %	0,7	1.675	0	25
Compound 3–1 (NTF-0,05%)	0,44	1.905	0	9
Compound 4–1 (NTF-0,09%)	0,44	1.919	0	10

2. Determination of the influence of a reinforcing additive on the strength properties of cement stone with expanding additives.

Table 3-Results of measuring the strength characteristics of cement stone

Compound	V/C	Bending strength, MPa		Ultimate compressives trength, MPa	
		2 day	7 day	2 day	7 day
Additive-Free PTC-I-G	0,44	2,9	3,8	10,8	15,4
Additive-Free PTC-I-G -G	0,7	1,5	2,6	4,5	13,8
Compound 1	0,7	1.97	2,95	5.53	8,7
Compound 2	0,7	3.0	4.37	6,71	12,2
Compound 3	0,44	3.9	5.57	17.26	More 22
Compound 4	0,44	3.5	5.52	13.2	More 22

Table 3 shows that cement slurries № 3 and No. 4 showed good results, but the composition which contains; KMD-5 %; NTF-0.05 %; PPV-0.25 %; Floss-0.3 % at W/C 0.44 has the highest strength (Goncalves et al., 2014).

Study of the impact resistance of cement stones containing reinforcing and expanding additives

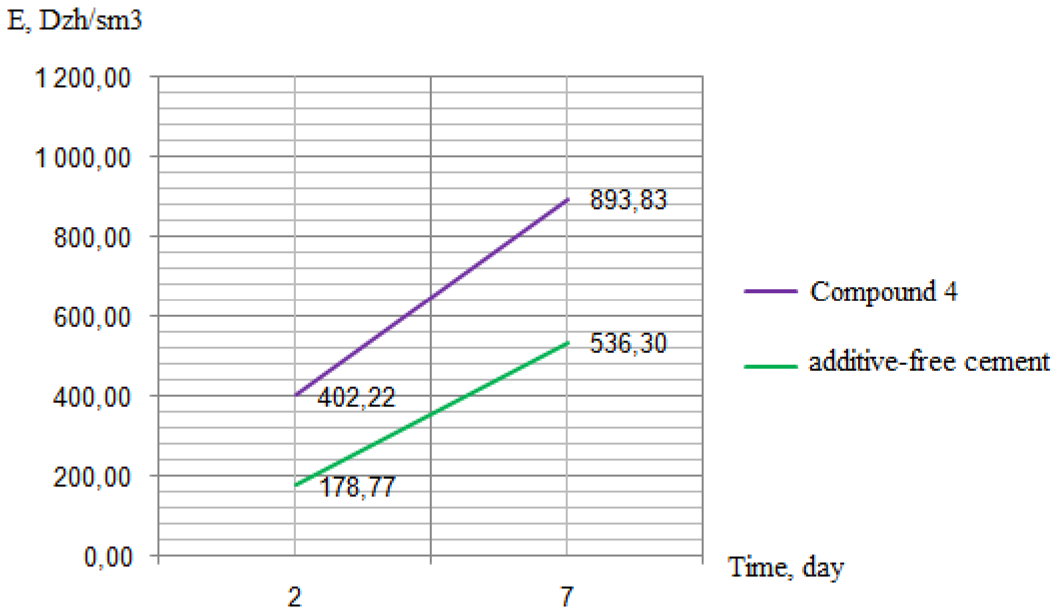


Figure 3. Change in impact resistance of cement stone during hardening of 2 and 7 days.

Grouting stone composition 4 relatively no additive cement stone showed good results when hardening 2 days and 7 days.

Evaluation of the influence of a reinforcing additive on the rheological properties of the cement slurry

Table 4 - Results of measuring the rheological properties of the cement slurry

Compound	V/C	PV, мPa*c	DNS, Pa	SNS, 10 c, Pa	SNS, 10 min, Pa
Additive-free PC	0,7	33,0	9,3	3	5
Additive-free PC	0,44	81,5	23,3	11	13
Compound 1+ EXR-250 0,5 %	0,7	32,3	8,1	1	3
Compound 2+EXR-250 0,7 %	0,7	29,1	8,0	0	2
Compound 3+EXR-250 0,1 %	0,44	75,3	21,6	10	11
Compound 4+EXR-250 0,2 %	0,44	73,1	21,0	10	10

It can be seen from Table 4 that it was necessary to use an additive based on hydroxyethyl cellulose to ensure that the rheological parameters were consistent. For W/C 0.44, EXR-250 was added at 0.1 % and 0.2

% concentrations. For a water-cement ratio of 0.7, these additives were used but with concentrations of 0.5 % and 0.7 %.

Influence of a reinforcing additive on the adhesion of a cement stone containing an expanding additive with metal.

Table 5-Results of measuring the adhesion of cement stone

Compound	V/C	Adhesion, MPa (2 day)	Adhesion, MPa (7 daY)
Additive-Free PTC-I-G	0,44	12,5	19,7
Additive-Free PTC-I-G	0,7	4,2	5,8
Compound 1+ EXR-250 0,5 %	0,7	4,9	6,2
Compound 2+EXR-250 0,7 %	0,7	4,9	6,4
Compound 3+EXR-250 0,1 %	0,44	12,9	20,3
Compound 4+EXR-250 0,2 %	0,44	14,0	21,3

All presented compositions with W/C 0.7 and W/C 0.44 showed insignificant results in adhesion relative to cement without additives, but nevertheless, the results obtained correspond to the requirements.

Conclusion

Cement stone has insufficient deformation strength when exposed to shock dynamic loads, which can lead to destruction and leakage of the annulus.

At the design stage, it is necessary to take into account the dynamic loads that will arise during further work in the well, such as pressure testing, hydraulic fracturing, etc. It is also necessary to regulate the requirements for the elastic properties of cement stone in order to assess its deformation resistance.

The introduction of fiber helps to increase the strength of the cement stone, its resistance to shock loads, and also increases the sedimentation stability of the solution.

Fiber can be used in absorbent formations as a bridging additive in cement or drilling fluid to prevent loss of process fluid during severe losses.

One of the most important advantages of fiber is the possibility of its use as a gas-blocking additive, which makes it possible to exclude gas penetration into the annulus during the WOC period.

Expanding additive DR-CT provides the main expansion of the cement stone in the first 2 days. Subsequently, the expansion is insignificant, which has a positive effect on the strength of the cement stone by reducing internal stresses during the formation of a strong structure of the cement stone.

An increase in water loss always reduces the amount of expansion of the cement stone during hardening by increasing the distance between the hardening products. The use of fiber reinforcement compensates for the negative impact of an increase in the water-cement ratio by transferring tensile stresses to the hardening products through the reinforcing fibers in the cement stone.

The use of fluid loss reducers did not lead to a significant change in the adhesion of cement stone with limiting surfaces for cement stone from the same density of cement slurry in the same hardening time.

Reducing the water-cement ratio, increasing the density of the cement slurry and increasing the duration of hardening of the cement stone gave a significant increase in adhesion.

Reinforcement of backfill materials provided an increase in the strength of the cement stone from the same density of the cement slurry in the same hardening time.

Reducing the water-cement ratio, increasing the density of the cement slurry and increasing the duration of hardening of the cement stone gave significantly the strength of the cement stone, both in bending and in compression.

The use of a reinforcing additive led to a decrease in water loss and water separation of cement slurries at the same water-cement ratio.

The use of fluid loss agents did not lead to noticeable changes in rheological parameters, since the main role in this process belongs to plasticizers. Reducing the water-cement ratio from 0.7 to 0.44 significantly increased all the rheological characteristics of cement slurries. To regulate the rheological characteristics, the additive EXR-250 was added to the main composition, which made it possible to meet the requirements. These composition changes did not lead to a significant impact on other processing properties such as strength and water-retaining properties.

Cement stone containing reinforcing (polypropylene fiber) and expanding additive showed good results compared to cement stone without additives.

Anknowlegement. Water consumption of crops. Irrigation norms of crops by regions. Irrigation modes watering methods. Adoption of the mode and method of irrigation as a basis for planning and organizing water use and water supply.

REFERENCES

Kaz Energy. The national energy report. P. 232. (2021). https://kazenergy.com/upload/document/energy-report/National Report 21_en.pdf. (in Eng).

Kireev A.M., 2015. New developments for remedial cementing [Novy`erazrabotkidlyaremontno-izolyaczionny`khrabot] Modern technologies for well workover and enhanced oil recovery.Development prospects.- Pp. 17–24. (in Russ.).

Shilov I.A., 2017. Selection of the most effective well killing fluids and assessment of their influence in laboratory modeling [Podbornaiboleee`ffektivny`khzhidkostejglusheniyaskvazhin i oczenkaikhvliyaniyaprilaboratornommodelirovanii]. I.A. Shilov, A.I. Nevolin. Oilfield business. № 12.- P. 84. (in Russ.).

Gregatti A., Carvalho G., Piedade T. and G. Campos, 2015. "Cementing in Front of Saline Zone and Carbonate Reservoir with Presence of CO_2." Paper presented at the OTC Brasil, Rio de Janeiro, Brazil. doi: https://doi.org/10.4043/26314-MS. (in Eng).

Agzamov F.A., 2011. Modeling of dynamic impacts on the well support based on the finite element method [Modelirovanie dinamicheskikh vozdej stvijnakrep` skvazhiny` naosnovemetoda konechny`kh e`lementov] F.A. Agzamov, A.V. Samsykin, I.M. Gubaidullin, M.A. Tikhonov, S.Yu. Semenov, R.A. Mulyukov., Oil and gas business. № 4. – Pp. 18–24. (in Russ.).

Samsykin A.V., 2007. The use of reinforcing additives to increase the sealing ability of cement stone in well lining [Primenenie armiruyushhikh dobavok pripovy`shenii germetiziruyushhej sposobnosti czementnogokamnya v krepiskvazhin] A.V. Samsykin, F.A. Agzamov, A.S. Sherekin. Drilling and oil. № 2. – Pp. 36–38. (in Russ.).

Tikhonov M.A., 2013. Improvement of fibroreinforced backfill materials: dis. cand. tech. [Sovershenstvovanie fibroarmirovanny`kh tamponazhny`kh materialov] Sciences: 25.00.15. Tikhonov Mikhail Alekseevich. - UGNTU. - P.174. (in Russ.).

Agzamov F.A., 2017. The results of calculating the loads arising from dynamic and impact action in the casing as a justification for the requirements for the strength of cement stone [Rezul`taty` raschetanagruzok, voznikayushhikh pridinamicheskom i udarnomvozdejstvii v obsadnoj kolonne, kakobosnovanietrebovanij k prochnosticzementnogokamnya] F.A. Agzamov, A.O. Belousov., Oil. Gas.Innovations - 2017.- № 10.- Pp. 60– 64. (in Russ.).

Orynbayev S., Amanbayev E., Alimbayev B., Beglerova S., Myktybekov B., 2019. Internal corrosion propagation in curved sections of steel pipes.News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences. 4(436). Pp. 213–22. http://dx.doi.org/10.32014/2019.2518-170X.116. (in Eng.).

Bu Y., Tian L., Guo B., Wang C. and Sun B., 2020. Experiment and simulation on the integrity of cement ring interface in deep water shallow formation. *Journal of Petroleum Science and Engineering*, *190*. Pp. 107–127. http://dx.doi.org/10.1016/j.petrol.2020.107127. (inEng).

Erofeev V., Kalashnikov V., Karpushin S., Rodin A., Smirnov V., Smirnova O., Moroz M., Rimshin V., Tretiakov I. and Matvievskiy A., 2016. Physical and mechanical properties of the cement stone based on biocidal Portland cement with active mineral additive.In *Materials Science Forum* Trans Tech Publications Ltd. (Vol. 871. Pp. 28–32). http://dx.doi.org/10.4028/www.scientific.net/MSF.871.28.(in Eng).

Stel'makh S.A., Shcherban' E.M., Beskopylny A., Mailyan L.R., Meskhi B. and Dotsenko N.Y., 2021. Enchainment of the coefficient of structural quality of elements in compression and bending by combined reinforcement of concrete with polymer composite bars and dispersed fiber. *Polymers*, *13*(24). Pp. 43–47. http://dx.doi.org/10.3390/polym13244347 (in Eng).

Quercia G., Chan D. and Luke K., 2016. Weibull statistics applied to tensile testing for oil well cement compositions. *Journal of Petroleum Science and Engineering*, *146*. Pp. 536–544. http://dx.doi.org/10.1016/j.conbuildmat.2009.11.009. (in Eng).

Abtahi S.M., Sheikhzadeh M. and Hejazi S.M., 2010. Fiber-reinforced asphalt-concrete–a review. Construction and Building Materials, 24(6). Pp. 871–877. http://dx.doi.org.10.1016/j.conbuildmat.2009.11.009. (inEng).

Galishnikova, V.V., Kharun, M., Koroteev, D.D. and Chiadighikaobi, P.C., 2021. Basalt fiber reinforced expanded clay concrete for building structures. *Magazine of Civil Engineering*, (1 (101)). P.10107.(inEng).

Agzamov F.A., 2013. Influence of fiber reinforcement on the properties of backfill materials [Vliyaniefibroarmirovaniyanasvojstvatamponazhny`khmaterialov] F.A. Agzamov, M.A. Tikhonov, I.N. Karimov. Territory Neftegaz.- №. 4.- Pp. 24–25. (in Russ)

Rozhkov S.Yu., 2020. Influence of the volume of fiber concentration on the strength indicators of cement stone with dispersed reinforcement [Vliyanieob`emakonczentracziifibry` naprochnostny`epokazateliczementnogokamnyapridispersnomarmirovanii] S. Yu. Rozhkov, V.P. Ovchinnikov, O.V. Rozhkova., Bulatov Readings. - Pp. 306–310. (in Russ.).

Goncalves R., Tajalie A.F. and A. Meyer, 2014. "Overcoming Lost Circulation While Cementing RiserlessTophole in Deepwater." Paper presented at the Offshore Technology Conference-Asia, Kuala Lumpur, Malaysia. Pp. 1–8 doi: https://doi.org/10.4043/24764-MS. (inEng).

Agzamov F.A., 2016. Investigation of the effect of reinforcing additives on expansion in lightweight cements. [Issledovanie vliyaniy aarmi ruyushchih dobavok narasshirenie v oblegchennyhcementah] Agzamov F.A., A.A. Becbaev. Territory Neftegaz.– № 1. –Pp. 11–19. (in Russ.).

Ahmed A., Gajbhiye R., Elkatatny S., Kalimur R., Muhammad S., Pranjal and Prahlad Yadav, 2018. "Enhancing the Cement Quality Using Polypropylene Fibers." Paper presented at the SPE Trinidad and Tobago Section Energy Resources Conference, Port of Spain, Trinidad and Tobago. Pp. 1–11. doi: https://doi.org/10.2118/191189-MS. (in Eng).

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