SOCAR Proceedings

Reservoir and Petroleum Engineering

journal home page: http://proceedings.socar.az

ACID-BASED CEMENT SLURRY WITH CONTROLLABLE PROPERTIES

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A b s t r a c t

Intensive occurrence of sand related problems in wells diminishes oil flow rate and leads to heavy expenses on production and equipment maintenance. Hard geological factors on field bedding, heterogeneity of reservoir porosity and permeability, strict constraints on physicochemical property of oil and produced water restrict the efficient application of several available methods and technologies for sand control. The increasing densification of sand related problems at late stages of development gives rise to implementation of different type of workover. There exist several backfilling compositions with a number of draw-backs to control sand influx from the reservoir into the well. With the purpose to work out more effective technology to ensure the consolidation of reservoir there was developed a new grouting mortar. This slurry contains cement, hydrated aluminum silicate and 7-8% hydrochloric acid solution. Barrier of grouting mortar has high resistance and adhesive characteristics and penetrates much deeper into pores increasing consolidation efficiency.

Keywords:
Pydrated aluminosilicate;
Acid retardation;
Amount of sand;
Consolidation of rocks;
Destruction of layers;
Cement slurry;
Hydrochloric acid.

Introduction

As we know a number of complications that reduce production and negatively affect important production and economic performance emerge in the operation of oil and gas fields due to geological and physical and technological reasons. Along with it, natural and intense destruction of formation and its impact on operational process is of great importance. Regardless of the reasons of sand entry, well sanding always results in progressive oil inflow reduction and significant production loss. Intensity of sand in the wells reduces the ultimate recovery and leads to a large overhead cost for production, transportation and preparation of water, as well as equipment repair. At the same time wasteful consumption of energy reduces overall efficiency of the development of deposits [1-12].

In Azerbaijan oil fields under restrictions of sharp heterogeneity of production horizons availability of sand producers is natural and considerable oil reserves are taken off during intensive sand entry. In this regard, there is an urgent need to develop measures taking into account particularities of certain object. Wells that compose operative stock of «Azneft» PU and distribution of maintenance overhaul are shown in figures 1 and 2.

Analysis of operative stock and nature of maintenance overhaul on «Azneft» PU indicates that the amount of sand in the well production varies within a wide range, resulting in serious complications.

Complex mining and geological conditions of deposit occurrence, filtration-capacitive heterogeneity of reservoirs, severe restrictions on the physical and chemical oil and formation water properties limit the possibility of effective use of many known methods and techniques for sand control.

Tendency to increase the intensity of well sanding in the late stage of development requires different type repair works, the main of which in «Azneft» PU are:

- undamaged completion;
- application of gravel-slotted filter;
- sand barriers in the borehole zone;
- sand plug liquidation.

There are various grouting compositions for regulating sand entry. The disadvantages of these cement slurries are, firstly, reduced spreadability, which leads to increased hydraulic resistance when transporting cement slurry into the iopbottom zone, and secondly, lack of cement stone expansion and, as a consequence, lack of flush contact with adjoining environments (bottom-hole zone rocks), in the third - increased filtering, which can lead to filtration of tempering liquid solution when forcing-through cement slurry into the reservoir [13-15].

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http://dx.doi.org/10.5510/OGP20200300444

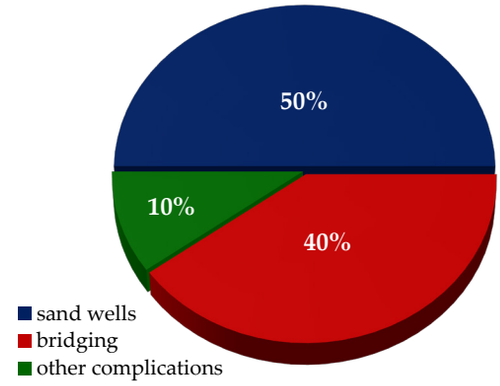

Fig.1. Wells that compose operative stock, «Azneft» PU

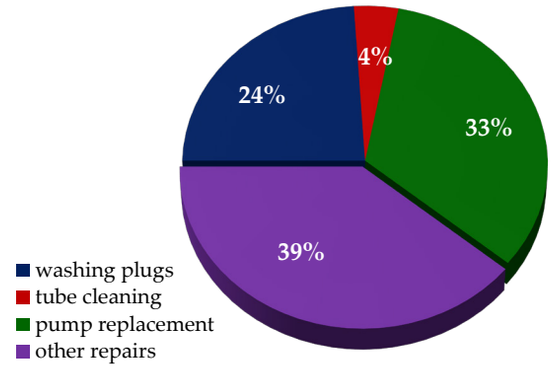

Fig.2. Distribution of maintenance overhaul, «Azneft» PU

The optimum cement design

Given the above mentioned shortcomings experimental studies have been conducted in laboratory conditions in order to develop more efficient technology for consolidation of near-wellbore rocks.

As a result of laboratory tests cement slurry consisting of oil-well cement, rock (hydrated aluminum silicate of alkaline elements (Na, K, Ca, Mg) · Ca $[Al_6 \cdot Si_{30} \cdot O_{72}]$ · 20 H_2O) and aqueous hydrochloric acid (*HCl*) has been proposed as the material to prevent rock destruction at wellbore area and to limit sand entry. For *HCl* and cement reactions retardation, control of initial and final set of cement slurry, as well as cement stone porosity and permeability control the addition of hydrated aluminosilicate into the composition have studied. Hydrated aluminum silicate of alkali elements is selected from Aydag deposit of the Azerbaijan Republic. This is a sorbtion, ion-selective and catalytic material with high strength properties. Cement slurry and stone are mainly characterized by increased flowability leading to reduction of hydraulic resistance during transport into the bottom-hole zone, improved adhesion, strength properties and reduced filtration which prevents premature filtration of the tempering liquid solution. Displacement of cement clinker with HCl triggers hydration and hydrolytic dissociation reactions characterized by a series of chemical and physico-chemical processes providing durable and permeable rock-like concrete.

Experimental procedures

In developed composition the permeable barrier is obtained due to availability of dry cement, carbonate, lime, silica, alumina, magnesium, aluminum, iron and many other components, some of which easily react with *HCl*. Interaction in the wellbore and near-wellbore which occurs in the process of injection causes gas release forming additional pores in the produced barrier. Injected «aerated» solution in the bottom-hole zone gradually stiffens and forms a stable, uniform strength and isotropic-permeable barrier. Prepared cement slurry and formed cement stone retains its stability at high pressures and temperatures, as well as erosion by groundwater seepage.

Permeability and strength of the cement stone

Laboratory experiments have shown that permeability and strength of the cement stone change depending on the concentration of hydrochloric acid. Test results are shown in figure 3.

As seen from figure 3 with densification of HCl permeability of cement stone increases leading to cement strength retrogression. Further densification of hydrochloric acid over 9% leads to degradation of mechanical-and-physical properties and at HCl concentration over 11%, an inadhesive crumbling mass forms.

Temperature factor

Further, as described in [16] cement stone samples were made of the investigated acid-based cement slurry (with 7% HCl) with rock addition. Accordingly, we have investigated the additive percentage impact on cement stone strength and permeability at different temperature ranges. Test results are shown in figures 4 and 5.

As is clear from figure 3, along with increasing the amount of additive in the mixture the strength increases by 20-25% under different temperature ranges. A system containing from 3 to 5% additives is characterized by maximum strength. The colloidal nature of the additive in HCl solution slows down diffusion rate of hydrions in solution forming a protective layer on the surface of cement powder particles, accompanied by acid with cement retardation. Retardation of reaction increases the depth of cement slurry penetration into the formation as well as increases the efficiency of rock consolidation [17].

Mathematical model of the cement stone

Mathematical model of the cement stone strength dependence on the amount of rocks at variety of temperature ranges is well described by quadratic equations:

at t = 20 °C $y = -0.001\,x^2 + 0.02x + 65.02$
at t = 60 °C $y = -0.001x^2 + 0.027x + 65.04$
at t = 100 °C $y = -0.001x^2 + 0.021x + 65.07$
at t = 140 °C $y = -0.001x^2 + 0.027x + 65.09$

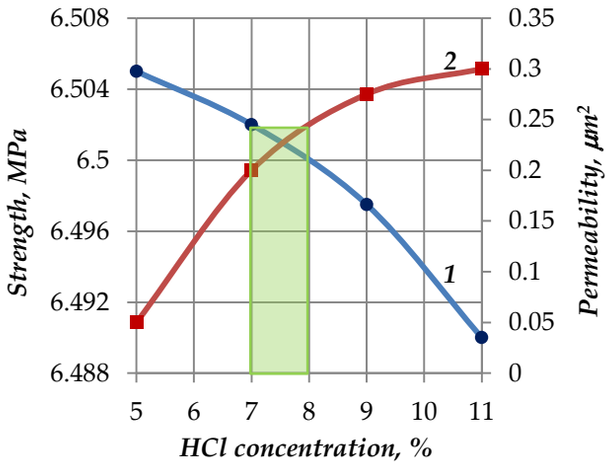

Fig.3. Dependence of strength and permeability of cement stone on *HCl* concentration
***1*- strength; *2*- permeability**

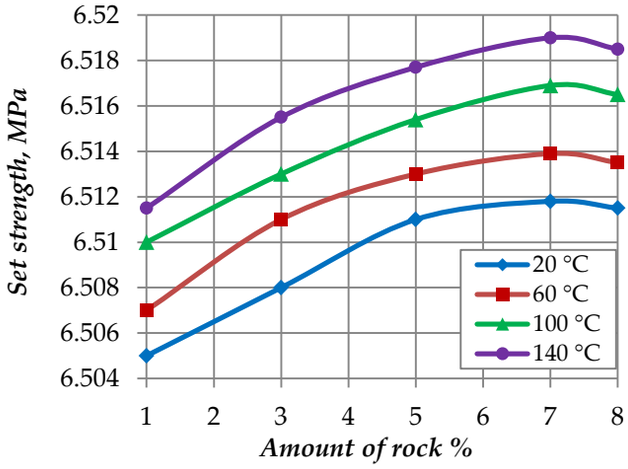

Fig.4. Dependence of set strength on amount of rock under varying temperature

Permeability of cement stone also increases depending on the amount of additive and decreases with increased ambient temperature, as shown in figure 5. Mathematical model of cement stone

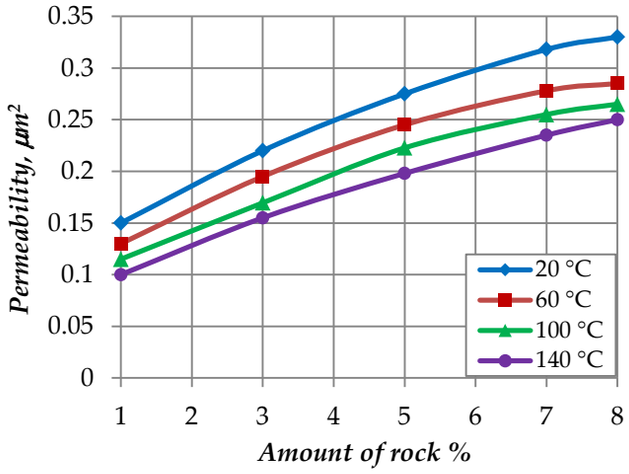

Fig.5. Dependence of cement stone permeability on amount of rock under varying temperature

permeability dependence on amount of additives at various temperature ranges is well described by quadratic equations:

at t = 20 °C $y = -0.001x^2 + 0.042x + 0.109$

at t = 60 °C $y = -0.002x^2 + 0.041x + 0.089$

at t = 100 °C $y = -0.001x^2 + 0.036x + 0.079$

at t = 140 °C $y = -0.001x^2 + 0.031x + 0.07$

Setting time

Initial and final sets are main factors influencing the process success when consolidation of loose rocks in the vicinity of borehole. Some shutdowns occur due to various failures during the process in deep wells. Increased setting time is required to prevent maturing of cement slurry in the tubing and string. Further investigations were carried out with regard to the setting time of cement slurry, depending on the amount and temperature of the rock. The results are shown in figures 6 and 7.

As a result of laboratory tests a composition for consolidation with high strength properties, consisting of oil-well cement, rock and 7-8% HCl solution was proposed. The amount of the additive makes 3 to 5% by weight of dry HCl. During the process the backfill suspension obtained by mixing these components, stabilizes loose and unconsolidated rock near wellbore, to a high degree preventing and limiting entry of mechanical impurities (sand, scale), thus expanding area of the process implementation, which enables its use in less and in deeper sanding wells.

Conclusions

1. Acid-based cement slurries with controlled technological properties, prepared with the addition of natural hydrated aluminosilicates of alkali elements, meet the requirements of work technology on stabilization of loose and unconsolidated rocks near the wellbore.
2. Application 3-5% of rock additives in 7-8% HCl solution based cement slurries reduces the period of hydrochloric acid aggressive action and allows the suspension to penetrate more deeply into the pores improving consolidation efficiency.
3. Since rock added to cement slurries is crook-veined and has developed inner surface, acting as «molecular sieves», with size sufficient to penetrate the liquid medium, but not solids.
4. Besides rock additives improve physical and mechanical properties of cement stone, which in turn makes a sand barrier acid, heat resistant and durable without visible signs of destruction.

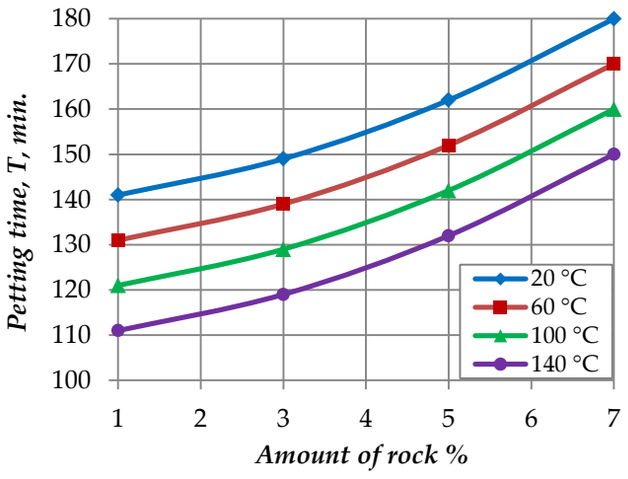

Fig.6. Dependence of initial setting time of cement slurry on the amount of rock at various temperatures

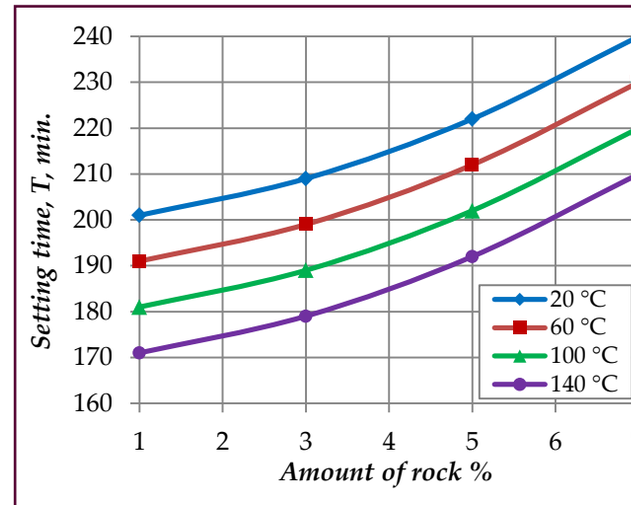

Fig.7. Dependence of final setting time of cement slurry on the amount of rock at various temperatures

Литература

1. Сулейманов, Б. А. (1997). Об эффекте проскальзывания при фильтрации газированной жидкости. Коллоидный журнал, 59(6), 807-812.

2. Сулейманов, Б. А., Байрамов, М. М., Мамедов, М. Р. (2004). О влиянии скин-эффекта на дебит нефтяных скважин. *Геология, геофизика и разработка нефтяных и газовых месторождений*, 8, 68-70.

3. Сулейманов, Б. А. (1997). Теоретические и практические основы применения гетерогенных систем для повышения эффективности технологических процессов в нефтдобыче. *Диссертация на соискание ученой степени доктора технических наук. Баку: АГНА.*

4. Сулейманов, Б. А. (1995). О фильтрации дисперсных систем в неоднородной пористой среде. *Коллоидный журнал*, 57(5), 743-746.

5. Suleimanov, B. A., Latifov, Y. A., Veliyev, E. F., Frampton, H. (2018). Comparative analysis of the EOR mechanisms by using low salinity and low hardness alkaline water. *Journal of Petroleum Science and Engineering*, 162, 35-43.

6. Сулейманов, Б. А., Велиев, Э. Ф. (2016). О влиянии гранулометрического состава и наноразмерных добавок на качество изоляции затрубного пространства в процессе цементирования скважин. *SOCAR Proceedings*, 4, 4-10.

7. Suleimanov, B. A., Ismayilov, F. S., Dyshin, O. A., Veliyev, E. F. (2016). Selection methodology for screening evaluation of EOR methods. *Petroleum Science and Technology*, 34(10), 961-970.

8. Сулейманов, Б.А., Исмайлов, Ф.С., Велиев, Э.Ф., Дышин, О.А. (2013). О влиянии наночастиц на прочность полимерных гелей, применямых в нефтедобыче. *SOCAR Proceedings*, 2, 24-28.

9. Сулейманов, Б. А. (2011). Промывка песчаной пробки газированными жидкостями. *SOCAR Proceedings*, 1, 30-36.

10. Панахов, Г. М., Сулейманов, Б. А. (1995). Особенности течения суспензий и нефтяных дисперсных систем. *Коллоидный журнал*, 57(3), 386-390.

References

1. Suleimanov, B.A. (1997). Slip effect during filtration of gassed liquid. *Colloid Journal,* 59(6), 749-753.

2. Suleimanov, B.A., Bayramov, M. M., Mamedov M. R. (2004). The skin effect and its influence on oil well production. *Geology, Geophysics and Development of Oil and Gas Fields*, 8, 68-70.

3. Suleimanov, B. A. (1997). Theoretical and practical applications of heterogeneous systems in the oil production technology. *Dissertation for the Degree of Doctor of Sciences in Technics. Baku: ASOIU.*

4. Suleimanov, B.A. (1995). Filtration of disperse systems in a nonhomogeneous porous medium. *Colloid Journal,* 57(5), 704-707.

5. Suleimanov, B. A., Latifov, Y. A., Veliyev, E. F., Frampton, H. (2018). Comparative analysis of the EOR mechanisms by using low salinity and low hardness alkaline water. Journal of Petroleum Science and Engineering, 162, 35-43.

6. Suleimanov, B. A., Veliyev, E. F. (2016). The effect of particle size distribution and the nano-sized additives on the quality of annulus isolation in well cementing. *SOCAR Proceedings,* 4, 4-10.

7. Suleimanov, B. A., Ismayilov, F. S., Dyshin, O. A., Veliyev, E. F. (2016). Selection methodology for screening evaluation of EOR methods. *Petroleum Science and Technology*, 34(10), 961-970.

8. Suleimanov, B. A., Ismailov, F. S., Veliyev, E. F., & Dyshin, O. A. (2013). The influence of light metal nanoparticles on the strength of polymer gels used in oil industry. *SOCAR Proceedings,* 2, 24-28.

9. Suleimanov, B. A. (2011).Sand plug washing with gassy fluids. *SOCAR Proceedings,* 1, 30-36.

10. Panakhov, G. M., Suleimanov, B. A. (1995). Specific features of the flow of suspensions and oii disperse systems. *Colloid Journal,* 57(3), 359-363.

11. Al-Darbi, M.M., Saeed, N.O., Ajijolaiya, L.O., Islam, M.R. (2006). *Petroleum Science and Technology*, 24(11), 1267- 1282.

12. Gu, J., Chen, X. (2009). Research and practice on cement slurry of oil and gas reservoir protection. *Petroleum Science and Technology*, 27(16): 1845-1853.

13. Krapivina, T.N., Chernyshev, S.Y., Krysin, N.I. (2010). Expanding cement slurry with controlled technological properties. *RU Patent* 2452758.

14. Dan Mueller, T. (2008). Cement compositions useful in oil and gas wells. *US Patent* 7442249 B2.

15. Samsonenko, A.V., Samsonenko, N.V., Samsonenko, I.V., et al. (2007). The expanding backfill material. *RU Patent* 2301823.

16. Bulatov, A.I. (1982). Plugging materials and well cementing technology. *Moscow: Nedra.*

17. Katoshin, A.F., Yakimenko, G.Kh., Khlebnikov, V.N., et al. (2001). Acidic composition. *RU Patent RU* 173383.

11. Al-Darbi, M.M., Saeed, N.O., Ajijolaiya, L.O., Islam, M.R. (2006). Petroleum Science and Technology, 24(11), 1267- 1282.

12. Gu, J., Chen, X. (2009). Research and practice on cement slurry of oil and gas reservoir protection. *Petroleum Science and Technology*, 27(16): 1845-1853.

13. Krapivina, T.N., Chernyshev, S.Y., Krysin, N.I. (2010). Expanding cement slurry with controlled technological properties. *RU Patent* 2452758.

14. Dan Mueller, T. (2008). Cement compositions useful in oil and gas wells. US Patent 7442249 B2.

15. Samsonenko, A.V., Samsonenko, N.V., Samsonenko, I.V., et al. (2007). The expanding backfill material. *RU Patent* 2301823.

16. Bulatov, A.I. (1982). Plugging materials and well cementing technology. *Moscow: Nedra.*

17. Katoshin, A.F., Yakimenko, G.Kh., Khlebnikov, V.N., et al. (2001). Acidic composition. *RU Patent RU* 173383.

Цементная суспензия с регулируемыми свойствами на основе кислоты

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Реферат

Одним из факторов, влияющих на снижение технико-экономических показателей нефтяных скважин при эксплуатации является пескопроявление. Разработан и протестирован в лабораторных условиях тампонажный раствор на основе портландцемента, природного горного камня - цеолита и 7-8% соляной кислоты. Цементный состав обладает высокими прочностными и адгезионными свойствами, а его текучесть позволяет намного глубже проникать в поры тем самым повышая эффективность уплотнения призабойной зоны скважины. Также исследовано влияние температуры на тампонажный раствор и цементный камень.

Ключевые слова: гидратированный алюмосиликат; кислотостойкость; количество песка; уплотнение горных пород; разрушение пород; цементный раствор; соляная кислота.

Xüsusiyyətləri tənzimlənən turşu əsaslı sement suspenziyası

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Xülasə

Məqalədə göstərilir ki, neft quyularının istismarı zamanı onun texniki-iqtisadi göstəricilərini aşağı salan amillərdən biri laydan məhsulla çıxarılan qumdur. Quyularda qum təzahürünün qarşısının alınması məqsədilə xlorid turşusu, sement və təbii seolit daşından ibarət tamponlayıcı tərkib işlənmişdir. Tamponlayıcı məhlul portland sement, təbii dağ süxuru- seolit və 7-8%-li xlorid turşusu əsasında hazırlanmış və laborotariya şəraitində tədqiq edilmişdir. Hazırlanmış tərkibin axıcılığı onun quyubi zonanın dərinliklərinə nüfuz etməsinə imkan verir, möhkəmliyi və keçiriciliyi yetərincədir. Tədqiqatlarda temperaturun sement məhluluna və daşına təsirinə də baxılmişdır.

Açar sözlər: nəm alyumosilikat; turşuya davamlılıq; qumun miqdarı; dağ süxurunun sıxlığı; sement məhlulu; xlorid turşusu.