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ANALYSIS OF THE EXISTING METHODS FOR ELIMINATION OF CEMENT SLURRY LOSSES WHILE WELL CEMENTING

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ABSTRACT

Successful casing cementing has to provide a reliable sealing of thief formations directly during drilling throughout each of them. Therefore, in this article we consider the problems of qualitative well cementing under low formations pressures conditions. A comparative qualitative analysis of currently in use materials, which are added into cement slurry to regulate its physico-chemical properties (such as circulite, haydite, tufa, and different surface-active materials, etc), is provided in the article. Also mud filter cake influence on the quality of cementing is considered. We defined the mud filter cake removal during wellbore preparing, which is the most optimum measure to provide a qualitative cementing.

We suggest the most convenient complex of measures for eliminating of cement slurry losses while it's pumping into a well and in this article we have discussed the oil and gas wells construction problems in conditions of low bed pressures typical for the South Mangyshlak oil fields in Kazakhstan.

It is well known that there are a range of unsolved questions, which restrain further intensification of oil and gas wells drilling in such conditions.

Today in conditions of the South Mangyshlak, it is possible to solve the problem by following ways:

- By using two-stage cementing,
- By development new backfill recipes which have low density, high strength, and good adhesion ability,
- By using technology of cementing in low formations pressures conditions,
- By upgrading the technology of well conditioning for cementing of production casing.

Key words: Casing cementing, Mud filter, Mangyshlak oil fields in Kazakhstan, Oil and gas wells.

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INTRODUCTION

One of the main conditions of successful cementing of casing is a high quality isolation of intake beds directly after each of them was opened out. But, according to practice, sometimes intake beds, which are isolated while drilling, absorb cement grout while cementing because in many cases the density of a cement grout is greatly higher than the density of a mud.

The analysis of additives used currently

Much time is devoted to investigate problems related to use low density cement slurries. There are many light types of slurry with circulite, clayite, tufa and other additions as the fillers were developed[1].

It's established that adding to cement slurry different materials, which decrease its density, often make worse physical and mechanical-group parameters of the solution. It results in increasing of hydraulic resistance while pumping and results in decreasing of mechanical strength of the cement stone.

According to experience, it is known that utilization of light cement slurries with bentonitic clay addition or other fillers while opening out intake formations with utilization low density mud (benign mud, aerated solutions, pens and so on) results in making worse of cement slurry quality, cementing quality and demands additional isolating works.

In some oil-producing regions big volumes of light buffer fluids are used (water, chemical aerated clayey and other low density solutions). However, not always good results are achieved and always hydrodynamic pressure while cementing exceeds formation pressure in high permeable, crumbling intake rocks or exceeds the extreme hydro-fracture pressure values of rocks with low strength capabilities.

The influence of mud filter cake the cement quality

Mud filter cake, which occurs on the well walls as the result of water filtration out the mud into the permeable formation, greatly affects on formations' isolation quality. As the result of walling-up pore channels narrow and the resistance of filtering surface increases, which consists of rock and the filter cake[2]. A lot of investigators consider that the main reason of annular space flows is a physicochemical interaction between the cement slurry and the mud filter cake. According to the gas flow appearance hypothesis the mud filter cake dewaters, decreases in volume as the result of contraction that links to upsetting of the annular space containment. However, there is also a possibility of the gas flow

independently to 'there is or there is not' the filter cake, i.e. the filter cake deleting is an undesirable process. According to Kuznecov et al.[3] filtration of the cement slurry through the mud filter cake decreases a 20 times. Also Khairov[2] pointed that an intensive dewatering of the cement slurry facing high permeable formations while taking down filtration crust able to result the complications in cementing processes.

However the most of the investigators consider that the mud filter cake should be removed over a pay zone and inside the pay zone. When the mud filter cake is removed before cementing, the containment and the strength of the contact between the cement stone and the rock significantly increases. But the most of applicable methods to remove the mud filter cake are ineffective. The conditioning of a well also doesn't carry out its' own functions because the mud filter cake appears again and has the same thickness. Using different scratchers supposes rotating and reciprocating of the casing in pumping-in and pumping down of the cement slurry processes, which has to be supported by the whole complex of additional equipment that is not always technically accomplishable. Chemical methods of mud filter cake removing from the wellbore walls didn't find a wide using, mainly due to the using of corrosive acids and alkalis. In addition, they have high toxicity and they pollute the environment. A long time circulation of circulating fluid also doesn't let to remove mud filter cake fully because for that the velocity of circulating fluid in annular space must be about 3-5 m/sec.

A big amount of authors pointed that as the result of contraction process the mud filter cake and mud, which remained in stagnant zone, dewater and during this there a range of channels appear and by them fluid or gas moves. It also confirmed by investigations in that claim that the mud filter cake existing is one of the main ways of gas of fluid penetrations, because contraction effect, as it considered earlier, exists in the whole cemented wellbore.

However, mud filter cake removing from wellbore walls without additional measures able to bring to negative consequences as the result of losing of dissolution products of the pore space of cement stone, and first of all, calcium hydroxide. According to Ivanov[4], calcium hydroxide removing from cement stone more than 30% of its initial volume able to bring to significant decreasing of stone strength.

Using of aerated cement slurries

Lately one of the most rational casing cementing methods in low formation pressures is using of aerated cement slurry with addition of surface-active materials. For that hydrodynamic conformance of the casing cementing conditions to conditions of formations

completion is achieved by choosing the related aeration rate of cement slurry, adding surface-active substances and stabilizers. Here a significant attention is devoted to provide the complex of technological measures to prepare the wellbore to pull down the casing.

The disadvantages of the method are that additional facility (like surface-active substances, stabilizers) has to be used, and also additional measures to pulling down the casing are needed. The aerated cement slurry often doesn't respond to demanding quality of annular space filling with cement, although aerated cement slurry cavities have high cork up properties.

The most optimum method

As we think the most optimum method is the mud filter cake removing while wellbore preparing, For example, using vibro-effect and followed mudding of permeable formations by using special mudding compositions, which is pumped-in to the well immediately after the mud filter cake removed.

To provide reliable isolation of permeable horizons from each other and to provide rising of the cement slurry to a set level in the annular space it's needed to solve the complex of problems to eliminate lost of cement slurry while it's pumping-in. As such measures the following can be suggested:

1. Before cementing of a well it is recommended to do flushing with aerated mud for reliable wellbore cleaning from drilled rock.
2. To aerate the mud it is recommended to use such technical facilities which able to provide a high rate of aeration.
3. To develop technological methods, which able to provide plugging the pores and fractures of permeable horizons with air cavities,

Analysis of the current status of oil and gas wells drilling shows that one of the actual problems in drilling on the exploited oil fields is the problem of abnormal low formation pressures and as the result the problem of decreasing of hydraulic pressure on the bottom and on the walls of wells. Necessity in decreasing of hydraulic pressure occurs while drilling and while well completion. Such necessity in decreasing of pressure occurs:

- While drilling with decreased differential pressure in the bottom zone with purpose to increase technical and economical characteristics of drilling bits performance; while drilling in the intake formations with purpose to eliminate mud losses;

- While well completion – casing in conditions with low formation pressure's gradients and, especially, in conditions with abnormal low formation pressures; and well development with purpose to achieve fluid inflow from formation into the well and so on.

At the same time there are a range of unsolved questions on the problem, which restrain subsequent intensification of oil and gas wells construction processes in conditions with low formation pressures.

Nowadays the most of constructed wells are drilled with high repressions on the opened formations and the bottom of a well. It brings to plugging of pay-zones by dispersed phase of a mud in the wellbore zone, to quick reducing of drilling bits performance characteristics, and to lost circulation, while drilling and tripping operations. While casing cementing operations in conditions with low formation pressure's gradients and abnormal low formations pressures there is cement grout losses and it doesn't come up to the set level in the annular space.

Geology of the South Mangyshlak

In most cases the oil and gas fields of South Mangyshlak (Uzen, Zhetybay and other) have conditions where formations pressures are the same to the hydrostatic pressure with a little deviation. The most of wells are drilled with repressions to the formations from 2 MPa in 1100 m depth to 5-6 MPa in 2000-2200 m depths. It brings to significant reducing of drilling bits performance characteristics. While casing cementing there in many wells the cement doesn't rise up to the rated level because of losses while pumping-in.

Many drilling engineers and scientists analyzed and did many works to understand the reasons of low-quality well cementing, it's physical phenomenon origins, and technical and technological measures that directed to solve these problems[5,6]. However, the qualitative formations isolations and the providing set rising up of the cement in the annular space is still a very actual problem.

The main oil and gas reserves on the South Mangyshlak oil and gas fields, mainly, belong to callovian, bathonian, bajocian measures and in lower rate to albian and neocom measures.

The main oil production is done from six stories Upper Jurassic measures. The cross-section of these measures has often and unequal alternations of sandstones, siltstones, clays (or argillites) with a bit of clay-carbonate and carbonate rocks. One of the significant features of the stratums is their high shaliness.

The mineral origin of the clayey stuff of clayey intervals is virtually the same. Terrigenous stuff inclusion is approximately 0–30%. Generally, upper stratum intervals unstable and inclined to opens creating. Lower clayey intervals are defined on the caliper curves as nominal or approximately equal to nominal diameter of a well.

The stratal waters are high saline brines (up to 170 g/L).

By geothermal situations the fields belong to high temperatures regions. The average rate of geothermal gradient is 4.03^{o}C. The next geological features that typical to Uzen, Zhetybay fields affect on the successfulness while drilling and casing wells:

- Multihorizon field;
- High oil-bearing capacity;
- High complexity of geological cross-section, sharp heterogeneity of oil reservoir, significant differences in stratum thicknesses;
- Wide range of collecting properties of pay zones;
- Presence in cross-section of gas-saturated layers and gas caps;
- Presence of tectonic abnormalities
- Low rates of the gradients of hydraulic fracturing of formations;
- Insignificant differences between the initial formation pressure and hydrostatic pressure.
- The hydrostatical measures of Uzen field development conditions vary in wide ranges:
- There are zones with abnormal low or abnormal high formation pressure;
- There are differentials of formations pressure ΔP that differ from initial pressure gradient a 1.5–5 time.

It adversely affects not only on oil development process, but also on the quality of sealing of annular space because abnormal differentials of formation pressure able to bring to different defects appearance in the space in time of waiting of cement hardening.

Oil and gas well drilling in Uzen and Zhetybay oil fields of the South Mangyshlak

Drilling of the production wells in Uzen and Zhetybay is provided either inside the gas-pool outline or outside it.

Usually the rotary drilling is used in the fields. As the mud fluid the process water is used in the upper intervals of cross-section (down to clays of Middle Albian) with subsequent changing the water to drilled-out mud, which properties regulated by adding coal-alkali chemical agent.

The well design either single-casing (outside the gas-pool outline), which is provided for pull down 245 mm conductor to depth 200 m to overlap unstable rocks and intake zones, or double-housing (inside the gas-pool outline), which is provided for pull down 324 mm conductor and 245 mm protecting string to depth 600 m for overlap of intake zones with hydrogen sulphide separation from gas-bearing beds, and subsequent pulling down 140 or 146 mm flow tubing to set depth in 215.9 mm wellbore.

The main complications while drilling in the fields are showingss of oil and gas and lost circulation.

Lost return occurs when Albian-Cenomanian (270-700 m) and Jurassic measures of $XIII^{th}$ horizons (970-1100 m) are drilled using circulating fluid with 1180 Kg/m^3 density, which is necessary to drill XIV horizon.

The mechanism of complications appearing

Apparently, the mechanism of complications appearing in some wells is that in the area, while production, formations pressures of $XIII^{th}$ and XVI^{th} horizons are maintained by water injection and underlying horizons (XV – XXIII) are exploited with stable decreasing of formation pressure in them. As a result of this the density of mud, which is enough to open XIII and XIV horizons, becomes excess to open-out underlying horizons and in them the mud losses with increasing of shows of oil and water of upper horizons occurs.

In most cases, all of the shows of oil-gas and water are related to the irregularity of the water flooding of formations and to the features of field structure, consequently intrastratal water flows appear and irregular formation pressures distribution appears.

Water inflows appear in the wells which belong to injection row.

To eliminate lost circulations 1–2% polyacrylimide solution is added in mud that provides increasing of solution viscosity and eliminates its losses into intake stratums.

Cementation of producing casing, mainly, is single-stage and is done by direct cementing. Two-stage cementing is not used due to low depths of wells and insignificant well drilling time. The producing casing is cemented with portlandcement a 100 m upper

than pay zones, and remaining interval is cemented with light-weight cement slurry for "warm" wells. In the injection wells producing casing cementing should be done with portlandcement up to the surface, but due to low breakdown gradients in Uzen field (0,0142-0,0179 MPa/m) cementing of these wells is provided with backfill which is combination of portlandcement and light-weight cement slurry for "warm" wells. At the same time the upper part of cross-section (Cretaceous and Upper measures) are isolated with light-weight cement slurry for "warm" wells with density 1410-1430 Kg/m^3, and underlying part of the cross-section with typical portlandcement with density 1800-1830 Kg/m^3.

Using of the light-weight cement slurry for "warm" wells compensates low breakdown gradients and provides rising of cement up to the surface, but it doesn't provide a qualitative adhesion of cement stone with rocks and a good sealing annular space because of low strength of the light-weight cement.

According to above in Uzen field, there is the problem of well cementing only with portlandcement for "warm" wells with providing it's rising up to the surface appeared.

Today in conditions of the South Mangyshlak, it is possible to solve the problem by following ways:

- By using two-stage cementing
- By development new backfill recipes, which have low density, high strength, and good adhesion ability
- By using technology of cementing in low formations pressures conditions
- By upgrading the technology of well conditioning for cementing of production casing.

In the South Mangyshlak fields, there are the development of oil and gas production will be provided, and also there the prospecting and explorations for oil and gas will be done. That is why it is suggested to develop new special technology to construct wells in low formations pressures conditions, including all operations to drill the wells.

CONCLUSION

Thus, we considered different materials, which are used while cementing to eliminate losses, and found out its advantages and disadvantages. Also we discussed on the mud filter cake influence on the cement quality and suggested to remove the cake while

preparing the wellbore for cementing. In terms of all above, we suggested the complex of measures to eliminate cement slurry losses while it's pumping-in.

In the South Mangyshlak fields, there are the development of oil and gas production will be provided, and also there the prospecting and explorations for oil and gas will be done. Therefore, it is suggested to develop new special technology to construct wells in low formations pressures conditions, including all operations to drill the wells.

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