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Shallow Gas Well Cementing and Channeling Prevention Technology

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Abstract
Gas channeling has been a technical problem in the expert inside course of study at home and aboard which always happened after shallow gas well cementing, as well as a research exploring topic. The effective shallow gas well cementing technologies are analyzed, and a set of channeling prevention technical measures are summarized by taking the gas well cementing operation experiences into consideration.

Key words: Shallow gas well cementing technology; Channeling prevention; High strength low density cement slurry system; Expanding agent; Accelerator; Multi-purpose spacer fluid

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INTRODUCTION
The characteristics of shallow gas are shallow buried depth, loose overlying formation, low formation pressurization, leakage; it is difficult to take measures such as the downhole pressure balancing and the hydrocarbon reservoir stability. The gas channeling is fast when gas cutting happened, the measures of downhole pressure stability, leaking prevention and channeling prevention are limited. Due to oil and gas of shallow gas abnormal high pressure wells is animate, so the oil and gas channeling is fast during the process of drilling and cementing. The reaction of representation characteristic such as gas cutting, overflow and blowout are brief which lead to the ground can't take measures in time. All of these factors are difficult to ensure the quality of cementing. So shallow gas well channeling prevention and cementing are one of the technical problems that have been studied in well-cementing operation both at home and abroad.

1. DIFFICULTIES IN CEMENTING TECHNOLOGY
Shallow gas formation compressive strength is low and it always happens leakage on downhole. Due to the pressure of shallow gas is high and oil layer is undervoltage in some oil wells which contain shallow gas that have been mining for many years, so the density of drilling fluid can only maintain in a range of small value. It require that we should ensure the pressure stability of shallow gas and formation breakdown is prevented during the process of cementing. If we can't make sure the value of density, it will appear the phenomenon that diarrhea and vomiting. However, the cementing fluid have to have an accurate density value. For shallow gas cementing, we usually take step density or single low density cement slurry cementing system[1]. No matter we take which kind of slurry system, solid composition weight of low density cement slurry is small, so the slurry is not stable. The space between the solid phase particles is big, liquid-solid ratio is high, free water is more, it is difficult to control the loss of water. The development of low density slurry's intensity is slow, long weightlessness transition period during the overexploitation, the ability of slurry channeling prevention is poor.

Due to the formation of shallow gas well is thin, so contact time between borehole wall and preflush as well as slurry is short. The effective of flushing, entrainment and displacement is poor. Shallow gas formation compressive

strength is low, so we will control the pressure and discharge capacity in the process of cementing. In this situation, it is difficult to form turbulent flow or effective laminar for annular, the displacing efficiency is low, the ability of mud displacement and flushing of borehole wall is poor, as well as the wellbore can't get good cleansing, annulus mud will retention and the borehole wall will be greasy. Mud cakes will affect the intensity of cement stone and the quality of interface cementation, microclearance will be formed at the outside of casing easily. Eventually it will form the gas channeling passageway, gas upward from the gas migration and form annular gas channeling, under pressure phenomenon will be appear at well head. For example, there have annular gas channeling in some wells of Kazakhstan's North Buzachi Oilfield, the annular under pressure phenomenon appear at well head[2].

Shallow gas well cementing, slurry interval isolation is short. Cementing makes the efficiency advantage of multi-density many clot pressure stability slurry system, well head pressure compensation and controlis not fully realized. If the annular gas channeling happened during the process of cementing, control difficulty will be greatly, it is easy to cause the risk of annular overflow and blowout. In North Buzachi Oilfield of Kazakhstan, there exist the shallow gas and active surface water from 30 meters to 160 meters. In gas cap area such as area 6 and 10, they have shallow gas from more than ten meters, especially in the depth of 300 meters, there is high pressure gas formation, the value of pressure is 3.9 MPa. The pressure of lower reservoir fracture is low, equivalent fracture pressure is 1.62 g/cm^3. So it easily occur cementing quality problems such as annular gas channeling at top high pressure gas formation and poor lost-circulation bond quality.

2. GAS CHANNELING PREVENTION CEMENTING SLURRY TECHNOLOGY

2.1 The Performance Requirements of Gas Channeling Prevention Slurry System

2.1.1 The Performances of Quick Setting and High Early Strength

The action of quick setting and high early strength performances are though the hydration reaction of cement and reinforcing agent, minimize the chance of gas channeling in time by improving the early strength of cement.

2.1.2 Low Fluid Loss Performance

We should control the fluid loss, in order to ensure the stability of slurry. The fluid loss should be controlled within 50 mL and trying to reduce the amount of free fluid as far as possible.

2.1.3 Right Angle Stiffen Performance

Gas channeling always occur in the transition gel period of slurry. The shorter transition gel period, the stronger controlling ability of oil, gas and water of slurry system. So in order to prevent gas channeling, we should adjust the slurry to be the slurry which could realize RAS. Right angle stiffen effect of slurry is equal to shorten the stiffen transition, so we should ensure the slurry transition gel period less than 15 minutes by improving the ability of slurry channeling prevention.

2.1.4 Suspension Stability Performance

We can improve the stability of low density slurry by adding amount of suspending agents, improving the viscosity of base fluid as well as stopping the floatation and precipitation of solid phase materials. Then viscous force of free fluid between granules is enhanced, the migration resistance of gas between granules is increased, gas channeling prevention ability of slurry is improved.

2.1.5 Microdilatancy Performance of Slurry After Solidifying

Due to amount of suspending agents have been added to the slurry system, so after slurry solidified (the process of cement stone formation), the volume of slurry will not shrink, but expand. Well cementation interface can be formed and the phenomenon of gas channeling passageway which is caused by microclearance is reduced under the expansion state.

2.2 The Actual Application of Dilatancy Type Gas Channeling Prevention Slurry System

The application of North Buzach Oilfield in Kazakhstan is as follows.

Double-condensation slurry system is adopted to the surface cementing slurry. In order to ensure hydrostatic column pressure stability formation could be given in upper low density slurry and gas pay can be sealed by lower slurry firstly, we usually adopt 1.85 g/cm^3 quick setting slurry on the bottom and 1.56 g/cm^3 high strength low density slurry on the top[3-4].

The formula of 1.85g/cm^3 slurry (22℃): Class G cement, +5%PZW-A reinforcement, +1.8%G60S channeling prevention fluid loss, +3%CA903S coagulation accelerator, +0.1%G603 antifoamer. Slurry free fluid is 0, API fluid loss is 29 mL, flow index is 0.66, thickening time(22℃) is 114minutes, compressive resistance in 24 hours(22℃) is 13.9MPa.

The formula of 1.56g/cm^3 slurry (22℃): Class G cement +41%BXE600S, +2.4%G60S channeling prevention fluid loss, +3%CA909S coagulation accelerator, +0.1%G603 antifoamer. Slurry free fluid is 0, API fluid loss is 20 mL, flow index is 0.70, thickening time (22℃) is 152 minutes, compressive resistance in 24 hours (22℃) is 12.5 MPa.

Low density slurry system was adopted to the reservoir cementing slurry, the density is 1.56 g/cm^3. Formation breakdown was prevented by low density, the requirements of oilfield exploitation were meet by high strength and the strong ability of gas channeling resistance could inhibit gas migration problems in the process of slurry throat effectively.

The formula of 1.56 g/cm^3 slurry (34 ℃): Class G cement +41%BXE600S, +2.4%G60S channeling prevention fluid loss, +3%CA909S coagulation accelerator, +0.1%G603 antifoamer. Slurry free fluid is 0, API fluid loss is 16ml, flow index is 0.79, thickening time (34 ℃) is 168 minutes, compressive resistance in 24 hours (22 ℃) is 17.2 MPa.

3. SUPPORT TECHNICAL MEASURES

3.1 Reasonable Designing Ahead Fluid System, Improving Ahead Fluid Performance and Displacement Efficiency

Designing cementing ahead fluid system reasonably according to the depth of cementing, formation pore pressure, borehole status and drilling mud performance. Considering flush fluid and the density, type, quantity of spacer fluid combined with a variety of factors. Forerunner mud or leading slurry was adopted in order to reduce interval isolation slurry mixed up. We should segregate drilling fluid and ahead fluid effectively, as well as avoid contact pollution of residual drilling fluid and slurry, then improving the displacement efficiency, in order to ensure cementing quality in sealing segment[5].

The effect of ahead fluid system which was applied in North Buzachi Oilfield of Kazakhstan is good. Ahead fluid system is to avoid the happening of channeling and leakage. We develop BCS series multi-functional weighting spacer fluid which have both flushing and segregation effect in order to support system slurry. This kind of spacer fluid is mainly consists of BCS020S suspension agent, BCS021L desaturator and BCW600S weighting agent. It also has the characteristics of good thixotropy and suspension, adjustable density, as well as good compatibility of drilling fluid and slurry. The spacer fluid have flushing function, it can flush hole wall, casing wall and displace slurry, preventing magma between slurry and drilling fluid, improving displacement efficiency and cemented performance of slurry. Special weighting agent was adopted to weight up spacer fluid in order to ensure the equalization of spacer fluid system and improve hydrostatic column pressure of fluid, as well as prevent gas channeling.

3.2 Solving the Problems of Cementing Gas Channeling by Downhole Tools and Wellhead Device

For special formation and shallow gas cementing, we can use the external casing packer at the top of high pressure gas reservoirs. The location of external casing packer should be chosen at stable borehole which above 3-5 meters on the top of gas reservoir, in the hole which hole diameter is regular, closing the up channel of gas can solve the technical problems of shallow gas channeling successfully. Under the allowing condition of the downhole loading capacity of formation, we can take measures that wellhead annulus build the pressure waiting on cement to offset pressure loss because of slurry weight loss, and reduce the chances of gas channeling.

3.3 The Well Cementation Technology of Conventional Cementing in Combination with Annulus Cementing

For well cementation of complex wells, which are sprayed and leaked, conventional cementing can be used, the cement slurry is returned to the leakage zone firstly, and then immediately wellhead device is hung. Two pipelines of grouting are respectively connected with the casing head spool, and both sides of the pipe are simultaneously injected with the washing fluid from the annulus space and rapid setting low density cement slurry with equivalent volume of casing annulus. The benefit of the annular slip casting is that the friction and resistance is not acting on the leakage zone as the conventional cementing, and the leakage loss of the layer is increased. Because of lost circulation, the level of cement slurry will be down to a certain depth, after cement slurry thickening from the first annulus space, rapid setting cement slurry is injected into annulus space once again, to achieve the requirements of the upper and lower butt seal to the wellhead. The technology of conventional cementing in combination with annulus cementing is effective and complex cementing anti channeling measures with serious leakage of shallow gas well.

3.4 The Construction Technology of Variable Displacement Is Used in Cement Slurry System With Multi-Coagulation Step Density

According to the pore pressure of formation, the density and thickening time of cement slurry in different sealing section are established; based on the experimental data of formation fracture pressure and formation pressure, simulated construction parameters of different stages is calculated, the maximum dynamic liquid column pressure of construction is less than the leakage pressure of formation and the minimum hydrostatic fluid column pressure is more than the pore pressure of formation by variable displacement for the construction work, it can achieve the balance of downhole pressure and stable pressure of gas zone, in order to prevent circulation loss and gas channeling.

CONCLUSION

(a) We can select cementing slurry technologies which are apply to shallow gas channeling prevention by analyzing the cementing technical difficulties. Supporting cementing technology measures taken as gas channeling prevention measures and control methods can solve cementing technical difficulties of shallow gas channeling prevention. Combined with field application analysis in

cementing operation, good cementing effectiveness has been obtained. It also has guidance significance for similar shallow gas well cementing practices.

(b) Good gas channeling slurry system and downhole tools as well as ground control measures are important technological measures to prevent gas invasion and gas channeling. It can improve the cementing quality effectively by reasonable selection and comprehensive application and achieve good gas reservoir cementing.

(c) "Pressure three-balance" is the basic principles of shallow gas well cementing, it means the downhole pressure balance before cementing, construction and slurry waiting on cement. Any link of downhole pressure overbalance will lead gas channeling and blowout accident. Improving the displacement efficiency and avoiding slurry of interval isolation channeling pollution are the basic requirements of shallow gas well cementing gas channeling prevention in order to achieve annulus net densification.

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