SQUEEZE CEMENTING OPERATION TO CONTROL WATER PRODUCTION ON WELL OKTA-36 OF FIELD OKTA, EAST JAVA

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Abstract

This thesis mainly discuss about workover (Squeeze Cementing) evaluation Activity in OKTA-36 well of OKTA field, East Java. The choice to did a workover activity in this well was because the oil and gas production for this particular carbonate well has been depleted. The cause of this problem was the watering problem near wellbore as the problem was found by using the Chan's Diagnostics. Chan's diagnostics is one of a method to determine the watering problem by comparing days to the existing production data. To increase the oil and gas productivity of this well, the justification was to close the old perforation interval of 6300ft – 6330ft MD by squeezing cement activity and then move the perforation interval to 6195ft – 6205ft MD and 6220ft – 6230ft MD. To fix the wellbore problem caused by water, the interval of 6260ft – 6262ft MD was also squeezed. The choice of 6260ft -6262ft MD was based on the tightness of the formation because of the total loss characteristics of the well. The result shows that the workover activity was a success because of the massive increase in oil and gas productivity. The numbers for the production performance analysis after workover activities are the WHP of 925 psi, WHT of 122o F, FLP 280 psi, Choke 30/64", oil production 1242 BOPD, Water Cut 0% and Gas Production 0.950 MMSCFD

Keywords :workover, squeeze, cementing, Chan, Diagnostics, production, evaluation

Introduction

Workover is an activity which is conducted to a remedy well to achieve a better production. To break it down, two of the examples of well workover program are squeeze cementing and perforating new interval holes. Squeeze cementing is a process when the cement slurry is pressed under some pressure to a certain spot inside the well for repairing purposes. One of the main reasons is to isolate water under the wellbore. As for the perforating new interval holes is an activity to produce at new perforation interval inside the same wellbore. Both of these programs are important for developing or increasing the oil productivity

In this thesis, the analysis is about workover activity in OKTA-36 well of OKTA field. Because the production of this well has been depleted, workover process is a must to improve the oil and gas production. Before the perforation job can be done to make a new perforation, the repairing process of cement bonding in 7" production line is necessary to fix problem of water channeling near wellbore behind the casing. The repairing process would be squeezing light cement and isolate the old perforation interval of 6300 – 6330ft MD. This thesis mainly discuss about the operational process of workover starting from Rigging up operation until rig released of OKTA-36. The author also discussed a bit about the use of Chan's diagnostic to predetermine the problem of why the WOR and water cut in this particular well are very high before the workover process. Furthermore the logging reading of the new perforation interval is also discussed in this thesis.

General Fundamental Theory

Workover is an activity which is conducted to a completed well to achieve a better production. To break it down, two of the examples of well workover program are squeeze cementing and perforating new interval holes. Before a workover activity gets underway there are many kinds of analysis that could provide data about the problems, one of them is Chan's diagnostic. This diagnostic produces analysis that capable of differentiating whether the well is experiencing water coning or near wellbore channeling due to bad cement bonding. Finally, the prediction of new interval with logging tools is very important because the production flow depends on the results of the new perforated interval.

Fundamental Theory of Squeeze Cementing

In general, squeeze cementing is a process when the cement slurry is pressed under some pressure to a certain spot inside the well for repairing purposes. One of the main reasons on an oil well is to isolate water under the wellbore. There are reasons why the squeeze cementing is used:

1. Repair primary cement job
2. Channels
3. Voids due to losses
4. Shut-off produced water
5. Shut-off produced gas
6. Repair casing leaks
7. Abandon depleted zones
8. Selective shut-off for water injection
9. Seal lost circulation zone
10. Shut off fluid migration

To finish the squeezed cementing process, the volume of cement which is needed to finish the job is quite small, but it has to be placed in a good spot inside the well. Sometimes the main difficulty is to limit the cement against the wellbore. To contain this problem, a good plan is necessary especially in planning the cement slurry, pressure choice and the choice of technique. Some the techniques are:

1. High Pressure Technique
2. Low Pressure Technique
3. Bradenhead Placement Technique
4. Squeeze Tool Placement Technique
5. Running Squeeze Pumping Methods
6. Hesitation Method

Further about Squeeze cementing, there is also injection test. Injection test is performed to:

1. To make sure that the perforation is opened and ready to be entered by fluids
2. To get the cement slurry approximation rate of the injection
3. To predict the pressure when the squeeze is performed
4. To predict the amount of slurry that’s being used.

Design and Cement Suspension Preparation also important in making a successful squeeze cementing operation, the variables are:

1. Compressive Strength
2. WOC (Waiting On Cement) time
3. Water Cement Ratio (WCR)
4. Density
5. Fluid Loss Control
6. Volume Slurry
7. Slurry Viscosity
8. Spacers and Washers

Below are the steps for basic procedure of the squeeze cementing:

1. The upcoming cemented zone is isolated with retrievable packer or drillable bridge plug

2. Perforation is cleaned with equipment of perforation cleaner or can be opened again with back surging technique
3. The equipment of perforation cleaner is pulled out of hole (POOH) and if the drillable squeeze packer method is already chosen so the circulating equipment has to be installed
4. Places the equipment into the well to targeted depth
5. All pipes or casing had to be tested first and after that the formation breakdown can be determined
6. While letting the circulating valve opened above the retainer, spacer fluids is poured into the pipe followed by slurry. After that the second slurry is entered and finally by the sufficient amount of mud to enter half of the first fluids spacer into annulus.
7. Circulating valve is closed and the formation can be squeezed
8. After the squeeze pressure has finally been reached, the pressure can be hold for a couple of minutes. Furthermore if the formation isn't breaking or the valve is not leaking, the pressure can be stopped, circulating valve can be opened and the excess slurry can be taken out.
9. If the excess slurry can't be taken out, it's best that all of the equipment should be pull out of hole.

As for the Applications of the squeeze cementing, it has been widely used for some of these purposes below:

1. Fill the perforating channel or channel behind casing with cement to achieve tightness between casing and formation
2. controls high GOR
3. controls excess water or gas
4. repairs casing damage
5. covers lost circulation zone
6. protects production zone from fluids migration
7. isolates production zone entirely and permanently
8. repairs damaged primary cementing jobs
9. prevents fluids migration from abandoned zones or wells

Two of the problems which cause imperfection in cementing results are the emergence of channeling and micro annulus. Channeling is a symptom which appears when the cement successfully occupied the annulus room but not entirely around the veil and fills up the annulus room. Whereas, micro annulus is a tiny hollow space that formed between veil and cement or between cement with formation wall. This indication causes the bonding quality of cement to become bad.

Below are some of the test needs to be done to evaluate squeeze cementing:

1. Acoustic Log
2. Radioactive Tracers
3. Cement Hardness
4. Temperature Profile

Fundamental Theory of Logging

Well logging, also known as borehole logging is the practice of making a detail record (a well log) of the geologic formations penetrated by a borehole. The log may be based either on visual inspection of samples brought to the surface (geological logs) or on physical measurements made by instruments lowered into the hole (geophysical logs). Some types of geophysical well logs can be done during any phase of a well's history: drilling, completing, producing, or abandoning. Well logging is performed in bore holes drilled for the oil and gas, groundwater, mineral and geothermal exploration, as well as part of environmental and geotechnical studies. Logging Evaluation is divided into some parameters, such as:

1. Spontaneous Potential Log
2. Gamma Ray Log
3. Resistivity Log
4. Density Log
5. Cement Bond Log (CBL)

Fundamental Theory of Perforation

Cased hole completion technique is done by perforating production veil pipe which protects productive zone in order to create an effective fluid flow between formation zones and well hole. Before continuing, the

purpose of the perforation method is to make contact or connection between reservoir and well's bottom hole with an intention to make hydrocarbon fluid flows into the bottom hole of the well so that the production can be happened. The success rate of perforation process is largely influenced by pressure, whether it's hydrostatic or formation. The partition of this perforation condition is based on difference between those two pressure and usually differentiate into two condition, that are overbalance and underbalance.

The perforation technique that used either overbalance or underbalance are hugely determined the outcome of the whole perforation process in pursuit of upscaling the productivity of a well.

Chan's Diagnostic

A technique to determine excessive water and gas production mechanisms as seen in petroleum production wells has been developed and verified.

Based on systematical numerical simulation studies one reservoir water coning and channeling, it was discovered that log-log plots of WOR (Water/Oil Ratio) vs Time or GOR (Gas/Oil Ratio) vs time show different characteristic trends for different mechanisms. The time derivatives of WOR and GOR were found to be capable of differentiating whether the well is experiencing water and gas coning, high permeability layer breakthrough or near wellbore channeling.In general, there were three basic classifications of the problems. Water coning, multilayer channeling and near wellbore problems are most noticeable among others. Field experience showed successful job design would not be the same for different mechanisms. However, there are no effective methods to discern these differences. In reality, the problem could be very complex, and usually is the combination of several mechanisms taking place over a period of time and compounding one with the other. It can be concluded that the log-log plot of production data and the WOR provide more insight and information for well performance evaluation. It can be applied either for the entire well life or any chosen period, such as the waterflood period. With a detailed workover history, the results analysis improves the understanding of reservoir flow behavior and determines the predominant mechanisms of excessive water production. Below are some of the log-log plot of production data and the WOR.

Using the WOR' (time derivative of WOR), coning and channeling can be discerned. Furthermore, the change in slope of then WOR and WOR' and the value of the WOR' become good indicators to differentiate normal displacement and production behavior, multilayer water breakthrough behavior, rapid layer depletion and water recycling behavior. This technique has some advantages, such as:

1. It mainly uses available production history data

2. It can be used to rapidly screen a great number of wells.
3. It entails the best reservoir engineering principles and practices
4. It could yield results to form the basis for conducting a production mechanism survey, compare mechanisms between adjacent wells vs problematic production wells, and by area or by well pattern
5. With the WOR vs cumulative oil production plot and the oil rate decline curves, it would become an effective methodology to select candidate wells for water control treatments.
6. There should be more production and reservoir engineering opportunities and benefits by using this diagnostic technique as one further progress along this approach.

From figure 1 in the references chapter, the comparison between Water Coning and Channeling WOR can be observed. As for the figure 2, the Field Example of Near Wellbore Water Channeling.

Discussion

Before the workover activity was done in this well, the oil production of this carbonate base formation well is very low. Even worst, the water production was also very high and this well can really become water well if a workover activity wasn't done to this well. The following shows how much the water cut and water production ruining the production of oil and gas in OKTA-36, Flowing Well Head Pressure (FWHP) 280 PSI, Choke 40/64, Oil Production 99 BOPD, Water Production 1666 BWPD, Water Cut 94%, Gas Production 0.490 MMscfd, Cumulative of Oil Production 5003 bbls.

The first thing to do is to find the type of watering problem which causing the well to produced large sum of water. One of the methods is using the Chan's Diagnostic. Chan's diagnostic is a technique to determine excessive water and gas production mechanisms in petroleum production wells. For the case of OKTA-36 well problem after the use of this simple but sophisticated technique is near wellbore water channeling (Figure 2) behind casing. By using the WOR (Water Oil Ratio) and WOR' (time derivative of WOR) from the production data the problem can be discerned. The CBL reading also gave certainty about the poor cement bonding of OKTA-36. By using the CBL, the cement bonding can be seen as good or not by the Millivolts reading of the CBL were high or not. If the millivolts reading are high then it could mean that the cement bonding is bad and the water is entering the wellbore but if the millivolts reading are low then the bonding is in good condition.The justifications or solutions of this problem were to squeeze light cement in 7" prod. Liner to repair the poor cement bonding which causing water channeling problem near wellbore behind the casing and isolate the existing perforation interval (6300 – 6330ft MD) and creates new perforation in interval 6195 – 6205ft MD & 6220 – 6230ft MD (total of 20ft). This justification was made by speculating some variables. The first was to evaluate the logging and find the tight formation to perform the hesitant squeeze cementing in interval 6260ft – 6262ft MD. The choice to use tight formation was to prevent the pumped cement to be lost into the formation before the estimated thickening time. Even the characteristic of OKTANIA reservoir itself is total loss so the tight formation is very useful to prevent losses. The choice of new perforation interval was also using the variable of logging evaluation to find a good interval which can produce oil and gas in a good basis. After the Chan's Diagnostics and log reading has been done, the next step was to perform the squeeze cementing activity in the old interval of 6300 – 6330ft MD and 6195 – 6205ft MD. This interval was closed because it produced much unwanted water and very ineconomical for this well. The technique which applied for this squeeze cementing activity was hesitant squeeze cementing. The last squeeze cementing activity the interval of 6260 – 6262ft MD was done to repair the cement bonding of OKTA-36 wellbore. The poor cement bonding of this wellbore causing a problem called near wellbore water channeling. To fix this this problem one of the solutions is to perform hesitant squeeze cementing. Especially For this interval, the perforation was first done to open up the stymie before the squeeze cementing activity so that the cement slurry can enter the formation. Along the cementing activity, there were also 2 injectivity test to go with it. For both of this perforation activity, the placement technique which has been used was the drillable cement retainer. After both of the squeezes cementing activity has been done, the next step was to perform the perforation activity in interval 6195ft – 6205ft MD. The perforation activity condition for this particular well was underbalanced and the gun type is TCP Gun which has to be dropped after the perforation activity was done. The following is the production performance test after all the workover activity has been done: Well Head Pressure 925 PSI, Well Head Temperature (WHT) 122◦F, Casing Pressure (CP) 900 PSI, Flow Line Pressure (FLP) 280 PSI, Oil Production 1242 BOPD, Water Production 0 BWPD, Water Cut 0%, and Gas Production 0.950 MMscfd. From the Production Performance Test number above we can conclude there were significant raise for the oil and gas production per day. Furthermore, the Well Head Pressure for this well was also increase by significant margin. This means that the pressure loss inside the well had been managed quite well by the squeeze cementing. From this table the most important thing is zero number for water production and water cut means that the squeeze cementing activity for this particular well was a huge success back then because the main activity was to control water production. The casing pressure for this well was still quite high when this production performance was run but other variable are good.

Conclusions

To conclude this thesis, there are some important points that can be taken based on whole pages of this thesis

1. The purpose of squeeze cementing activity in OKTA-36 is to improve production of oil by the repairing process of cement bonding in 7" production line to fix problem of water channeling near wellbore behind the casing
2. The method which was used to find the watering problem was Chan's Diagnostic. Thus the result of the diagnostic's itself is near wellbore water channeling by comparing WOR and WOR' vs days from production data.
3. CBL was used to inspect the cement bonding quality. The result of the CBL observation is the bonding of OKTA-36 was quite bad by the reading from Fluid Compensated CBL Amplitude (CBLF), 40 MV is the highest.
4. Before squeeze cementing activity was performed, logging reading is necessary to determine the tight formation. Interval depth which used for the tight formation is 6260 – 6262ft MD. Logging reading was also used to determine the new 2 interval perforation of OKTA-36 which is 6195 – 6205ft MD and 6220 – 6230ft MD
5. New perforation was made because the old perforation wasn't producing good amount of oil and gas. Usually after the squeeze cementing activity, new perforation is usually made to create better flow rate
6. The type of formation in OKTANIA reservoir is carbonate which more likely to cause total loss so the choice of tight formation to squeeze the cement was the right choice
7. Squeeze cementing activity for OKTA-36 is a huge success with the increase of oil production of more than 100 percent and erased the water production and water cut percentage altogether.

List of Symbols

BPM = Beat per Minute, (minute)
CBL = Amplitude, (mV)
CP = Casing Pressure, (PSI)
GOR = Gas Oil Ratio, (scf/bbl)
FLP = Flow Line Pressure, (PSI)
FWHP = Flowing Well Head Pressure (PSI)
MD = Measured Depth, (ft)
Rmf = Mud Filtrate Resistivity, dimensionless
Rw = Water Resistivity, dimensionless
WOC = Waiting On Cement, (minutes)

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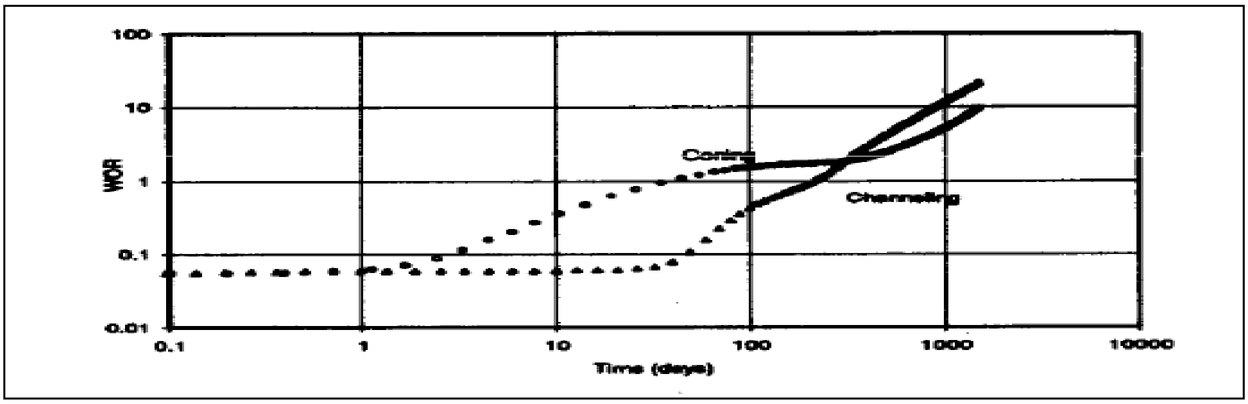

Figure 1 – Water Coning and Channeling WOR Comparison

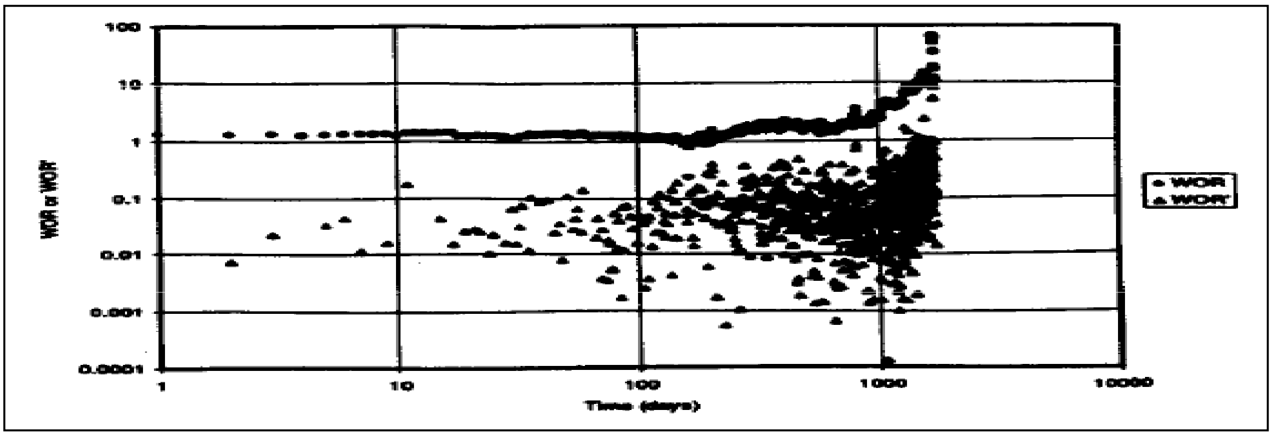

Figure 2 – Field Example of Near Wellbore Water Channeling