عدد خاص
بالمؤتمر الليبي الدولي للعلوم التطبيقية والهندسية
27-28- سبتمبر 2022
المجلّة الدولية للعلوم والتقنية
International Science and Technology Journal
ISTJ

Analyzing the Cement Plugs application to Cure Lost Circulation Zones in Belhedan Oil Field

Khaled Hasan Kaukau

Department of Petroleum Engineering, Faculty of Oil and Gas Engineering University of Zawia, Libya
k.kaukau@zu.edu.ly

الملخص

أحد أخطر مشاكل حفر الابار النفطية هو فقدان سائل الحفر. يصف مصطلح "فقدان الدورة" هذا الوضع. يمكن أن يحدث في التكوينات الصخرية خلال الحفر وايضا في التكوينات المتشققة بشكل طبيعي. فشل عملية السمنتة الأولية بسبب عدم وصول الإسمنت إلى الارتفاع المطلوب ، مما أدى إلى استمرار ضغط الغلاف والتآكل ، وخسائر سائل الحفر مما ينتج عنه تجاوز التكاليف المحددة للحفر ومخاوف الصحة والسلامة البيئية.

تتمثل أهداف هذه الورقة في وصف مشكلة فقدان دورة سائل الحفر وتقديم تركيبة سدادة إسمنتية لمعالجتها. تم دراسة استخدام السدادات الإسمنتية في ثلاثة آبار في حقل بلحيضدان الذي تديره شركة الواحة للنفط. وفقًا للنتائج ، تحدد كمية الإسمنت المستخدمة في كل سدادة ومدة فترة الفقد عدد سدادات الإسمنت اللازمة لكل بئر. بالإضافة إلى ذلك ، كل ما انخفض عامل الامتصاص ، يرتفع معدل فشل سدادات الإسمنت بعد حفرها.

Abstract

One of the most serious issues in drilling is mud loss. The term "lost circulation" describes this situation. It can be produced in formations through drilling as well as exist in naturally fractured formations. The failure of the primary cement job due to not getting the cement up to the desired height, which then resulted in sustained casing pressure and corrosion, the loss of the ability to perform work over activity on certain wells, and mud losses during drilling that resulted in cost overruns and HSE concerns.

This paper's goals are to describe the extreme lost circulation problem and present a cement plug formulation to address it. The use of a cement plug in three wells in the Belhedan field which is operated by Waha Oil Company is finally reported. According to the findings, the quantity of cement used in each plug and the duration of the loss interval determine how many cement plugs are needed for each well. Additionally, as the absorption factor declines, the failure rate of cement plugs after drilling rises.

Keywords: Mud losses, Cement plugs., Belhedan field.

1. Introduction

Lost circulation is best defined as the uncontrolled flow of whole mud into a formation [7]. This can happen in naturally cavernous, fissured, or coarsely permeable beds, or it can be purposefully created by fracturing the rock either hydraulically or mechanically, which creates a passageway for the fluid to traverse. The induced lost circulation occurs when the formation cannot support the effective stress put on it by the drilling fluid as a result of an excessively overbalanced situation. The most frequent cause of this issue is an excessive density of the drilling fluid [9].

Excessive drilling fluid density can be caused by poor or incorrect well planning (pore pressure and fracture gradient prediction), ineffective or nonexistent solids management, poor rheology, or inefficient hydraulics in the circulating system[9]. Any mechanical issue that results in an excessive pressure surge might lead to hole instability and lost circulation. Pump surges, bit and stabilizer balling, inadequate hole cleaning, excessively high pump flow rates, poorly designed hole geometry, and poor fluid characteristics, which make it challenging to stop circulation after the fluid has been stopped, are a few examples of these problems [2].

Circulation in a drilling well may be lost into preexisting open cracks. Huge apertures with structural strength, like large pores or solution channels, might cause circulation to be lost. The initial step after a circulation loss should be a diagnosis to determine where and why the loss is happening [1]. Lost circulation can be categorized as follows: seepage (up to 10 barrels per hour), partial loss (10 to 50 barrels per hour), severe loss (>50 barrels per hour), and total loss where no return at the surface [9].

1.1 Prevention of Induced Lost Circulation

Controlling static and dynamic pressures, as well as always keeping the total of these imposed loads below the rock's fracture limit, are the keys to preventing induced lost circulation [9]. The precise prediction of pore pressure and fracture gradient is at the heart of this well-planning dilemma. Second, drilling fluid characteristics need to be carefully watched over and kept within acceptable bounds. The most crucial component of keeping drilling fluid parameters acceptable is solids control, which is followed by monitoring rheology and hydraulics to reduce fluid gel strengths, annular pressure losses, and equivalent circulating density (ECD) [2]. Optimizing the bit hydraulics will help to prevent bit balling and thus lower aberrant surge and swab pressures [7].

1.2 Remedial Measures

A lost-circulation episode exacts a high price that is significantly greater than the cost of the remedies employed to heal it. Nonproductive time is caused by lost circulation, which also includes the price of rig time and all the services required to support the drilling operation. Although prevention is essential, there is also a top emphasis on effective repair strategies because lost circulation is so frequent. If lost circulation occurs, the zone must be sealed unless the geological circumstances allow for blind drilling, which is often unusual [7]. The typical LCMs that are typically combined with the mud to seal loss zones can be categorized into fibrous, flaked, granular, and a combination of fibrous, flaked, and granular materials. Course, medium, and fine grades of these materials are offered to seal low-to-moderate lost-circulation zones [6].

The use of various plugs to seal the zone becomes necessary in the event of significant lost circulations. Before installing a plug, it is critical to understand the position of the lost-circulation zone. There are numerous kinds of plugs employed by the sector, including Bentonite and diesel-oil squeeze (gunk plug), cement-bentonite-diesel-oil squeeze, and cement [10].

1.2.1 Remedial of Induced Lost Circulation

Loss of circulation materials is typically not very effective when induced loss of circulation occurs [8]. This is especially true if the mud has a high density of at least 14 lb/gal. Fine loss circulation material that doesn't absorb a lot of water should be used to make weighted mud. Then turn the pump off and keep an eye on the annulus' fluid level (the reduction in pressure due to the cessation of fluid flow may be sufficient to stabilize a minor loss.), next the hole should be filled with water or diesel (base fluid) if the fluid level is low and keep track of how many barrels are needed. To avoid a stuck pipe, the bit should be moved up into the casing if the loss is significant [5]. When there are only minimal losses and the hole seems stable after turning off the pump, an effort to reestablish full circulation at a lower pump rate is justified. Don't keep pumping if the loss keeps happening.

1.2.2 Remedial Measures of Naturally Occurring Lost Circulation

The measures here are similar to the measures used in induced lost circulation except that If the fluid level is invisible, fill the hole with water and keep track of the necessary number of barrels [3]. If the hole will not fill, either place a concentrated LCM pill or mix 10-15 lb/bbl LCM in the remaining mud in the pits and place it across the weak zone if the location of the loss zone is known. While waiting for the hole to heal, pull the pipe into the casing and replenish the mud volume [8]. Knowledge of the location will determine the course of action. In many cases, after spotting lost circulation material across the thief zone, the drill string can be removed from the hole without risk while it is healing. There are other places where, due to an anticipated flood of oil or gas, the drill string cannot be withdrawn while the fluid is out of sight and cannot be monitored. The type and concentration of lost circulatory material will vary depending on the specific circumstance [2].

1.3 Blind Drilling

When drilling is in the "blind" phase, no fluids that were utilized to facilitate the drilling operation can return to the surface. Blind drilling is the term used to describe the scenario that results from total lost circulation, which occurs when drilling fluids pass through the rock formation without returning [2]. Drilling blindness results when drilling engineers keep drilling into a rock formation even if all circulation has been lost [10].

1.4 Gunk Plug

Bentonite with diesel oil is frequently used as a gunk plug. The slurry is made of bentonite, cement, or polymers combined with oil. To seal the leaky zone, a tiny amount of the slurry is poured down a well that has lost circulation [3]. Pressure may or may not force the gunk plug into the zone. A viscous, gel-like substance with a high viscosity is produced when water in the down hole reacts with bentonite, cement, or polymers.

1.5 Balanced Cement Plug

The balanced cement plug method, or BCP, applies the balanced hydrostatic principle to the setting of cement plugs. In general, when we say "balance," we mean that the hydrostatic pressure in the annulus and at the end of the drilling string is equal [5 &10].

1.5.1 Equations of Balanced Cement Plug

Some equations are used to :

1) Calculate the cement volume needed.
2) Calculate the height of the spacer and cement before inserting the pipe.
3) Calculate the displacement volume needed to equalize the hydrostatic pressure on both sides. When the displacement is finished, you ought to have cement, spacer, or mud that is the same height [1,3 & 5].

1. $S_{oh} = \frac{{D_{oh}}^2}{1029}$ …………………………………………………………………... (EQ 4-1)

   where

S_{oh} = capacity of the open hole (bbl/ft)
D_{oh} = diameter of open hole (in).

2. $S_{tub} = \frac{I.D_{tub}{}^2}{1029}$ ……………………………………………..………………… (EQ 4-2)
where
S_{tub} = capacity of tubing (bbl/ft)
$I.D_{tub}$ = internal diameter of tubing (in).

3. $S_{ann} = \frac{(D_{oh}{}^2 - I.D_{tub}{}^2)}{1029}$ ………………………………………………………… (EQ 4-3)
where
S_{ann} = capacity of the annulus between tubing or drill pipe and open hole (bbl/ft).

4. $V_{cem} = L \times S_{oh}$ …………………………………………………………………… (EQ 4-4)
where
Vcem = volume of cement required for the job (bbl)
L = length of the column of cement in an open hole (ft).

5. $L_{cem} = \frac{V_{cem}}{(S_{tub}+S_{ann})}$ ………………………………………………………… (EQ 4-5)
Lcem = length of balanced cement plug (with work string in place) (ft).

6. $R_{excess} = \left(\frac{Vf_{cem}-V_{cem}}{V_{cem}}\right) \times 100$ …………………..………………………... (EQ 4-6)
where
R_{excess} = percentage of excess cement volume (%)
Vf_{cem} = final volume of cement used for the job (bbl).

7. $Va_{cem} = Vf_{cem} - \big((D - TOC) \times S_{oh}\big)$ ……………………………………. (EQ 4-7)
where
Va_{cem} = volume of cement absorbed by formation (bbl)
D = depth of work string (bottom of cement plug) (ft)
TOC = top of cement plug (ft).

8. $R_{Va_{cem}} = \left(\frac{Va_{cem}}{Vf_{cem}}\right) \times 100$ ……………………………………….………… (EQ 4-8)
where
R_{Vacem} = percentage of absorbed cement volume by formation (bbl).

9. $V_{disp} = S_{tub} \times [D - (L_{cem} + L_{sp2})]$ ………………………...………… (EQ 4-9)
where
V_{disp} =displacement volume (bbl)
L_{sp2} = length of spacer behind (ft) = V_{sp2}/S_{tub}

10. $V_{sp2} = \left(\frac{V_{sp1}}{S_{ann}}\right) \times S_{tub}$ ……………………………………………..……… (EQ 4-10)
where
V_{sp2} = volume of spacer behind the cement (bbl)
V_{sp1} = volume of spacer ahead of the cement (bbl).

11. $Vtot_{disp} = V_{sp2} + V_{disp}$.. (EQ 4-11)
where
$Vtot_{disp}$ = total volume of displacement (bbl)

2. Aim of Study

The information recorded from drilling reports was used to conduct calculations of the ideal balanced cement plug and then perform a comparison between the results of this calculation and the actual cement plug present in wells in terms of amounts of used fluids such as cement slurry, spacer, and displacing fluid.

3. Methodology

The importance of this study lies not in the calculations of the balanced cement plug but in how to obtain the information (Input Data) necessary to carry out these calculations such as the volume of spacer ahead cement, the top of the cement plug, the bottom of cement plug, volume of cement used for the job, number of cement sacks, depth of hole during the placement of cement plug, hole diameter, cement string diameter and the length of lost circulation zone. To obtain this information, many of the Daily Drilling Reports, DDR, have been reviewed for each well. Each well contains hundreds of daily reports and each report contains 24-hour drilling operation details.

In this study, the daily drilling reports of Waha Oil Company for wells V39, V36, and V33 in the Belhedan field were reviewed to study the cases of cement plug and fluid loss problems. During the review of the daily drilling reports, all the data and information related to the loss of circulation problem and cement plug process were recorded such as the depths at which the loss of circulation occurred whether partial or total losses, lithology of thief formation, tops of geological formation especially thief formation, the depth of Open Ended Drill Pipe, OEDP, before and after setting cement plug, number of cement barrels used, number of cement sacks used, type and density of used cement slurry, depth of cement plug bottom, Top of Cement, TOC, number of cement plug for each well, length of cement plug, length of thief zone and the drilling mud loss rate before and after cementing.

The information recorded from drilling reports was used to conduct calculations of the ideal balanced cement plug and for comparison between the results of this calculation and the actual cement plug present in wells in terms of amounts of used fluids such as cement slurry, spacer, and displacing fluid. The calculation was performed by using the above-mentioned equations and an excel sheet.

4. Case Study

Central Libya's Sirte Basin contains several oil fields, including the 1962 AC-discovered Belhedan field. With a porosity of 8.9% in the field and a depth of 6,500 feet, Gergaf Sandstone serves as a representation of the creation of an oil reserve. The study presents the calculation used for the cement plug process as a remediation method for loss of drilling fluid to Thief Formations (usually dolomite) problems of three wells in Belhedan Field which always occur in the 12¼" section of the hole. The study was conducted to compare the specifications of the actual cement plugs placed in the lost circulation zones and the ideal specifications of the calculated cement plugs such as the required volume of the cement slurry to cover the desired interval of lost circulation formation And to determine the efficiency of cement plug method in healing lost circulation zones. And also to determine the depths, lengths, and lithology's of the lost circulation materials and why the cement plug is used instead of Lost Circulation

Materials. As stated the study was conducted on the wells: V33, V36, and V39 in Belhedan Field. Data used in this study was gathered from the Daily Drilling Reports of the given wells.

4.1 Well V33

The location of the well lies in Belhedan field which is an oil field in the Sirt basin [4]. This well like the other adjacent wells has the problem of drilling fluid loss into problematic formations especially FASHA DOLOMITE while drilling a 12¼" hole section, the dolomite is known as high porosity and permeability formation made up of the dissolving action associated with the dolomitization process [4]. The total depth of the well is about 7360 ft. but the study will be focused on the (12¼" hole section) where the loss of drilling mud problems occurred. Tables (1 and 2) present the input data and calculation of the first three plugs out of five used in this well.

Table-1 Data Required and the calculation results for Balanced Cement Plug #1&2 in Well V33.

Plugs 1 and 2 input data		Plugs 1 and 2 output data	
Hole Diameter (in)	12 ¼	Hole Capacity (Open Hole) (bbl/ft)	0.1458
Drill Pipe Diameter (in)	5	Pipe Capacity (bbl/ft)	0.0177
Lost Circulation Zone Length (ft)	141	Annular Capacity (bbl/ft)	0.1215
		The yield of Cement (ft^3/sx)	1.685
Volume of Spacer Ahead Cement (bbl)	10	required cement column volume (bbl)	20.56
		Percentage of Excess Cement (%)	264.83
Current hole Depth (ft)	3846	Cement Absorbed by the formation (bbl)	60.71
Depth of open-ended Drill pipe (ft)	3846	Percentage of Cement Absorbed by Formation (%)	80.95
		Length of Balanced Cement Column (ft)	538.597
Cement Tagged Depth (ft)	3748	Mud to Displace Plug into Position (bbl)	57.278
Final Cement Volume (Used in Well) (bbl)	75	Volume of Spacer Behind Cement (bbl)	1.4618
		Total Volume of Displacement (bbl)	58.739
Number of Sacks (SXS)	250	Absorption factor (bbl/ft)	0.313-0.62

Table 1 represents the combination of plug #1 and Plug #2 calculations, this combination is due to the absorption of all cement in the first attempt and that means plug #1 cannot be calculated and no cement existed in the hole. As we see the thief zone absorbed about 60.7116 bbls of cement with an absorption factor ranging from 0.62 bbl/ft at the bottom to 0.313 bbl/ft for the rest of the cemented interval which is considered a high to a bit low absorption factor. Losses of 100 bbl/hr (16%) are obtained after filling the hole to test the losses because the plug didn't cover the full length of the thief zone.

A low amount of cement was pumped in cement plug #3 (as presented in table 2) to cover the short remaining interval. The interval covered by cement plug #3 is only partial losses interval without total losses and the absorption factor was as low as 0.21 bbl/ft. For plug four, The bottom of this cement plug is not placed on the bottom of the hole because the hole was filled with 70 bbl Hi Vis LCM Pill to work as a new base for plug cement#4. The hole was filled to test the losses and the result was no returns because it is obvious that the cement plug didn't cover the full length of the losses interval, especially the total losses depth at 3750 ft. Plug five is the last cement plug in well V33. The hole was filled with LCM Pill to work as a new base for the fifth cement plug, this plug nearly covered the full length of the losses interval

including the total loss zone.
After drilling cement plug #5 the mud returns percentage was about 73% and which means the five cement plugs succeed to eliminate the total losses but failed to cure the partial losses.

Table 2 Data Required and the calculation results for Balanced Cement Plug # 3 in Well V33.

Plug 3 input data		Plug 3 output data	
Hole Diameter (in)	**12 ¼**	**Hole Capacity (Open Hole) (bbl/ft)**	**0.1458**
Drill Pipe Diameter (in)	**5**	**Pipe Capacity (bbl/ft)**	**0.0177**
Lost Circulation Zone Length (ft)	**43**	**Annular Capacity (bbl/ft)**	**0.121**
		The yield of Cement (ft^3/sx)	**1.718**
Volume of Spacer Ahead Cement (bbl)	**10**	**required cement column volume (bbl)**	**6.269**
		Percentage of Excess Cement (%)	**144.04**
Current hole Depth (ft)	**3748**	**Cement Absorbed by the formation (bbl)**	**9.03**
Depth of open-ended Drill pipe (ft)	**3747**	**Percentage of Cement Absorbed by Formation (%)**	**59.024**
		Length of Balanced Cement Column (ft)	**109.87**
Cement Tagged Depth (ft)	**3705**	**Mud to Displace Plug into Position (bbl)**	**63.15**
Final Cement Volume (Used in Well) (bbl)	**15.3**	**Volume of Spacer Behind Cement (bbl)**	**1.46**
		Total Volume of Displacement (bbl)	**64.61**
Number of Sacks (SXS)	**50**	**Absorption factor (bbl/ft)**	**0.21**

4.2 Well V36

The total depth of the well is about 7323ft. but the study will be focused on the 12¼" hole section from) where the loss of drilling mud problems has occurred. In this well, six attempts were used to cover the whole length of losses interval and plug off lost caving and fractures. The 12¼" section was drilled with a 12¼" bit with full returns to 3680 ft; (FASHA DOLOMITE); a partial loss of mud returns was encountered at this depth and a total loss was encountered at 3724 ft. Continuing blind drilling with water to 3850 ft, spotting a Hi-Vis LCM Pill followed by 75 bbls of 14 ppg thixotropic cement plug on the bottom, tagging cement at 3559 ft. Spotting 50 bbls of HI VIS LCM pill followed by 75 bbls of 14 ppg thixotropic cement plug; (cement plug # 2); tagging cement at 3940 ft. Filling up the hole with water to test the losses, no returns. Spotting 50 bbls of HI VIS LCM pill followed by 75 bbls of 14 ppg thixotropic cement plug; (cement plug # 3); tagging cement at 3885 ft. Losses rate 240 bbl/hr. pumping 75 bbl of 14 ppg thixotropic cement; (cement plug# 4) tagging cement at 3669 ft. Drilling out cement from 3660 ft to 4526 ft with full returns, continuing drilling a 12¼" hole from 4526 ft to 4570 ft with full returns, and from 4570 ft to 4577 ft had partial losses.

The top of the Zelten formation is 4390 ft. continuing drilling a 12¼" hole from 4624 ft to 4670 ft with 20% mud losses. Spotting 50 bbls of HI VIS LCM pill followed by 50 bbls of 14 ppg thixotropic cement plug; (cement plug # 5); tagging cement at 4313ft. Drilling out cement from 4313 ft to 4670 ft with 80% mud returns, continuing drilling 12 1/4" hole from 4670 ft to 4856 ft with 73% mud returns. Spotting 45 bbls of HI VIS LCM pill followed by 75 bbls of 14 ppg thixotropic cement plug; (cement plug # 6); tagging cement at 3683ft. Drilling out cement from 3683 ft to 3880 ft with 100% mud returns. The casing was cemented with a multi-stage cement job with 350 bbls of 9.7 ppg lead slurry and 113 bbls of 15.8 ppg tail slurry in 1st stage and 214 bbls of 9.9 ppg lead slurry and 38 bbls of 15.8 ppg in the 2nd stage; 1.5 bbls of cement returned to the surface.

4.3 Well V39

This section was drilled with 12¼" bit with full returns to 3677 ft; (FASHA DOLOMITE); a total loss of mud returns was encountered at this depth. Continuing blind drilling with water to 3774 ft, spotting a Hi-Vis LCM Pill followed by 90 bbls of 14 ppg betonies cement plug on the bottom, tagging cement at 3706 ft. Spotting 100 bbls of HI VIS LCM pill followed by 90 bbls of 14 ppg thyrotrophic cement plug; (cement plug # 2); tagging cement at 3263 ft. Drilling out cement from 3263 ft to 3774 ft with full returns, continuing drilling 12¼" hole from 3774 ft to 7046 ft with full returns. Top of Gargef formation is 7038 ft. The hole was logged as per the logging program and reamed. 9 5/8", L 80, 43.5ppf, BTC casing was run to 7044 ft. The casing was cemented with a single-stage cement job with 534 bbls of 10.5 ppg lead slurry and 53 bbls of 15.8 ppg tail slurry; 10 bbls of cement returned to the surface.

5. Results and Discussion

5.1 Time Lost Due to Lost Circulation Problem

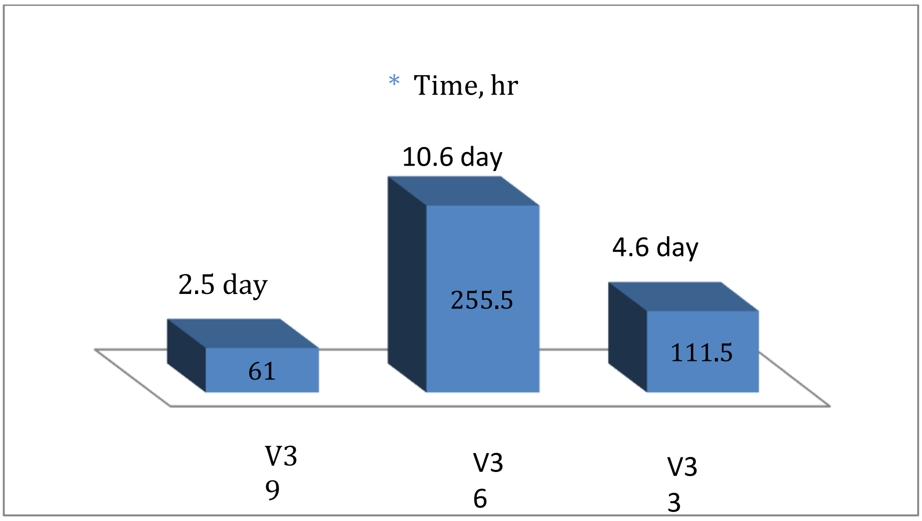

Figure 1 : Total Time Lost for Each Well

Figure 1 represents the time lost due to the loss of drilling fluid problem in hours and days. As shown in the figure the NPT decrease as the plug cementing attempts to achieve successive cement plug decrease. The highest NPT of 10.6 days is observed in well V36 because six attempts of cement plug were made to cure the losses and also because V36 has the longest thief zone interval (about 260 ft), this interval includes two geological formations FACHA DOLOMITE and KHEIR LIMESTONE. The second highest NPT of 4.6 days is observed in well V33 which has five attempts of cement plug. The most perfect drilling operation with the lowest NPT of 2.5 days was in well V39 due to its short thief zone thickness (about 97ft) present in FACHA DOLOMITE formation and because two attempts were only made to cure the losses.

5.2 Lost Time to Total Drilling Time of 12¼" Hole

The loss of drilling fluid problem has a vital effect on the time needed to drill 12¼" in terms of the excess time it caused and the additional expenditures resulting from the use of the rig for a longer time and the ratio of the lost time to the total time to drill 12¼" hole. The following Figure 2 shows the percentage of lost time caused by the lost circulation problem to the total time needed to drill a 12¼" hole and the ratio of additional costs caused by the same problem to the total cost of rig time for a 12¼" hole.

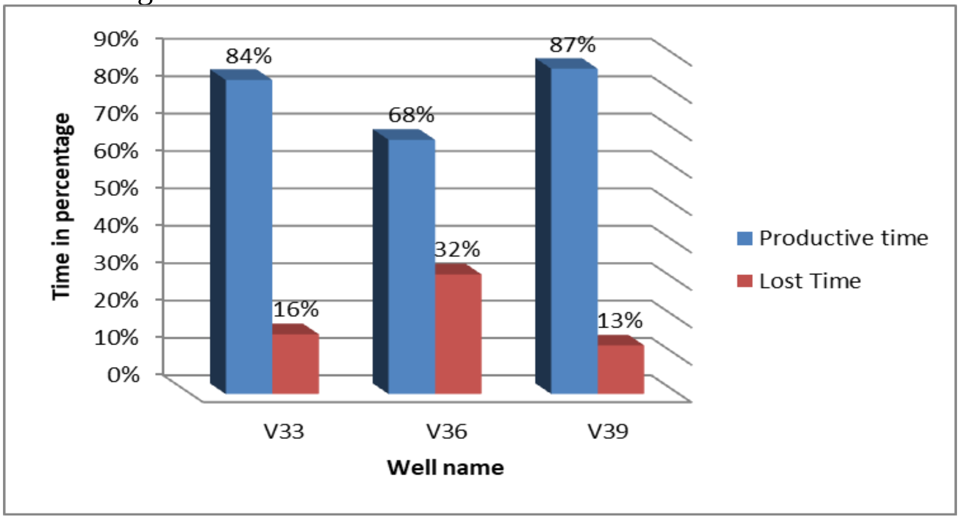

Figure 2 Ratio of NPT caused by L.C to Total Drilling Time for 12¼" hole

As seen in Figure 2 the lost time due to the lost circulation problem represents about 16% of the total time for well V33 and that means an increase in the cost of Rig time by16% (56,120 $). Also, it is observed that well V39 has the minimum NPT ratio of 13% (2.5 days) due to the experience obtained from the drilling of previous wells and it's considered one of the most successive wells in the area.

5.3 Mud Volume Losses

Figure 3 declares the amount of drilling mud present in hole sections 26", 17½", and 12¼" holes from the surface to the depth of the first total loss occurrence. This amount of drilling mud is equal to the amount of mud lost in the thief zone when the total loss occurred.

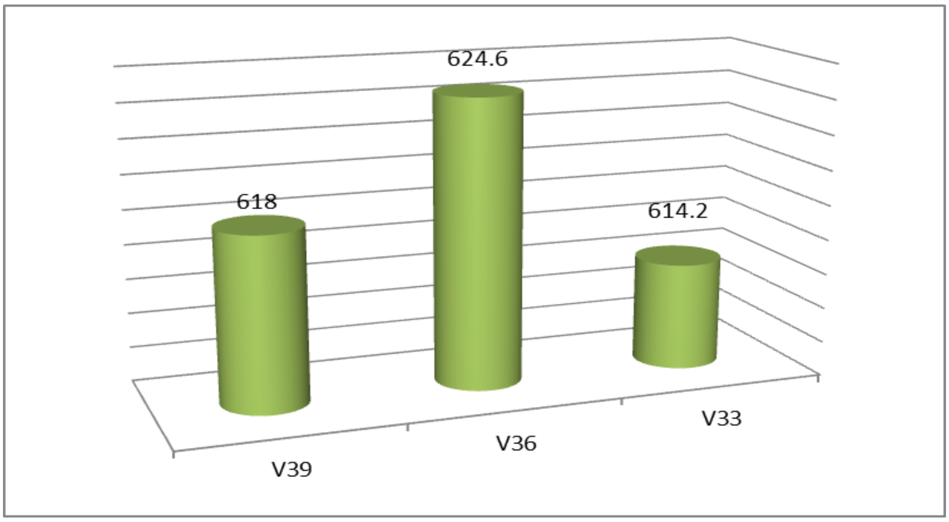

Figure 3 Estimation of Mud Volume Losses Due to L.C in the First Total Loss.

5.4 Actual and Planned Time of 12¼" Hole

Figures 4,5 and 6 show the difference between the planned time and actual time in several operations such as drilling, lost circulation, cementing, casing, and tripping for the three wells. In this study the focus is on drilling and lost circulation operations and as is obvious that the difference in time almost happened in both operations only, because the drilling operation stops as the lost circulation problem occurs.

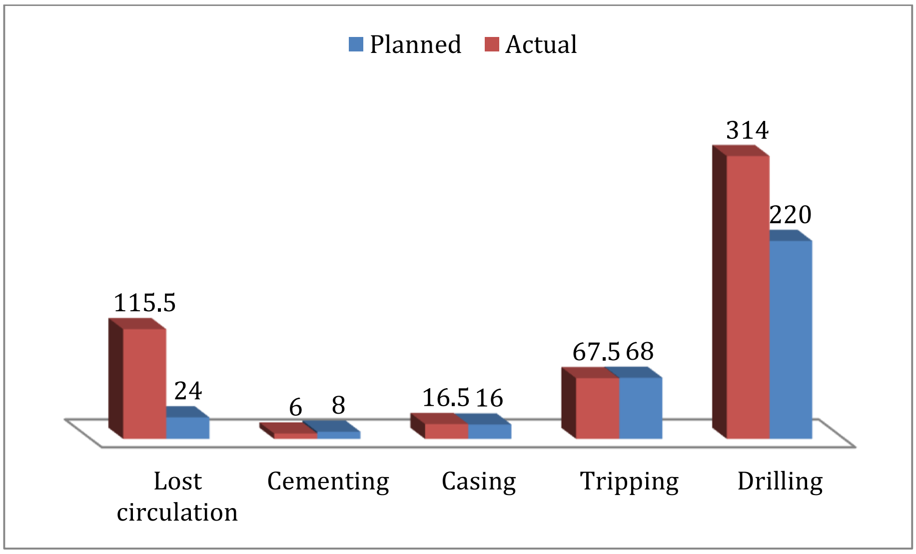

Figure 4 Actual and Planned Time in hours of Well V33.

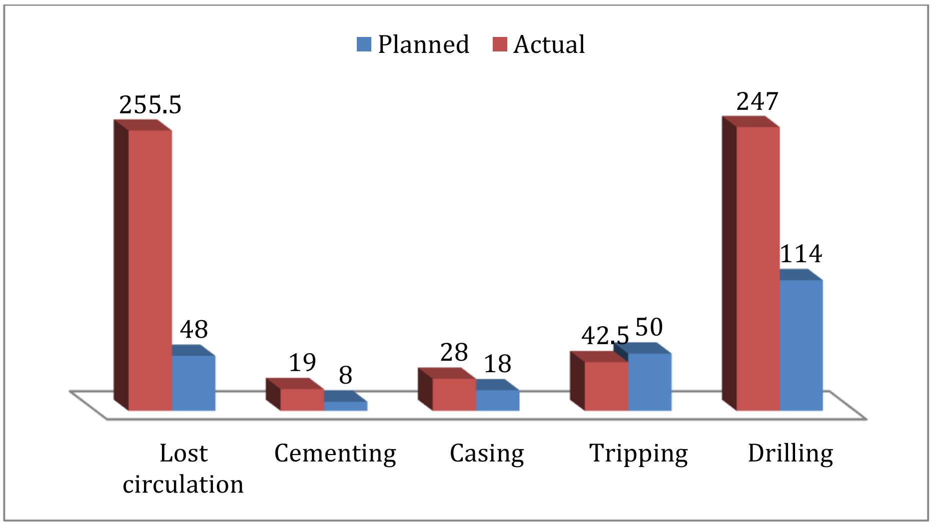

Figure 5 Actual and Planned Time in hours of Well V36.

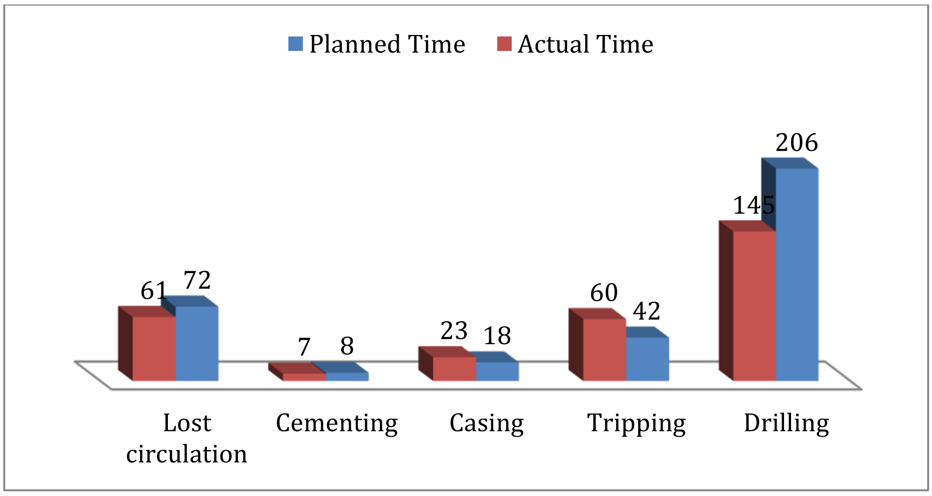

Figure 6 Actual and Planned Time in hours of Well V39.

5.5 Thickness and Lithology of Thief Zones

The dominant thief formation in this Belhedan field is FACHA DOLOMITE with little KHEIR limestone as a thief zone in well V36 by a ratio of 38%. Figure 7 shows the thickness of the thief zone estimation for each well.

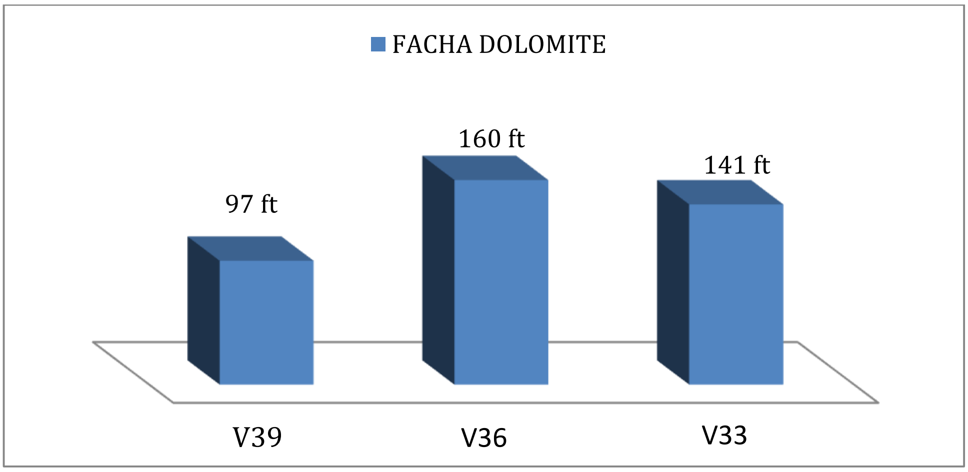

Figure 7 Thickness of Thief Zone Intervals for Each Formation.

5.6 Cement Plugs Used in Belhedan Field

Figure 8 shows the number of cement plugs used for each well. It has been noticed that the well V36 has the largest number of cement plugs (6 cement plugs) and well V33 with 5 cement plugs, it is also observed that wells V30 and V39 have the same number of plugs and the well V34 has no cement plugs because its thief zone was healed by using lost circulation materials and in the last comes the well V40 with only one cement plug used to cure the lost circulation zone and this indicates an increase in the geological understanding of the thief zone formation characteristics, ideal displacement rate, how much the depth should be blindly drilled and other effective factors. The volume of cement used to cure the lost circulation problem for each well is presented in figure 9.

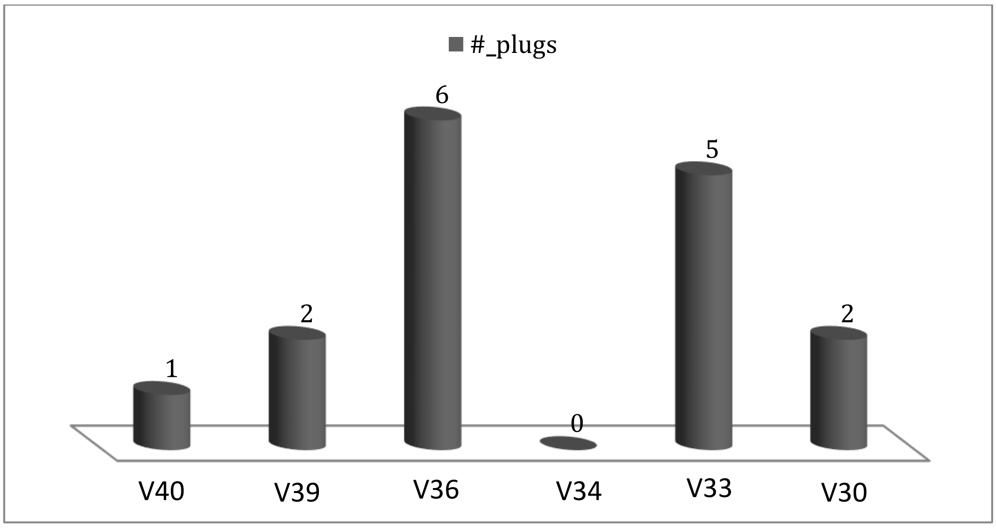

Figure 8 Number of cement plugs for some of Belhdan field wells

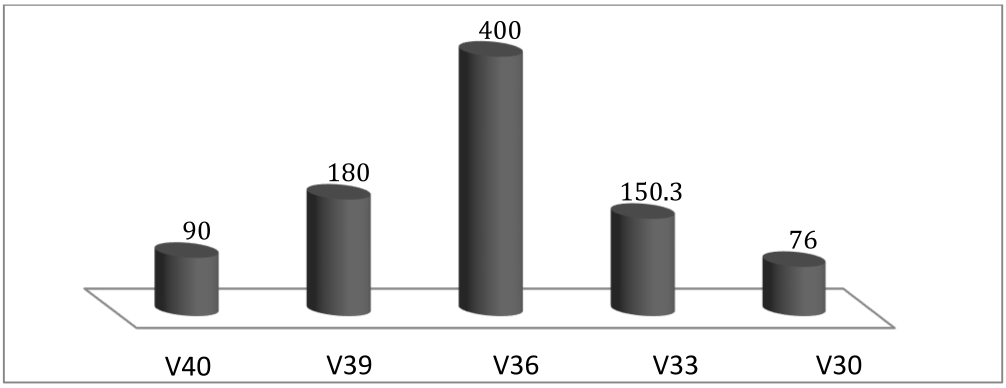

Figure 9 Volume of Cement in barrels used for cement plugs for Each Well.

5.7 The Relation Between Actual and Calculated Volumes of Cement

The following figures (10,11, and 12) illustrate the volume of cement required (Calculated) to fill the vertical distance between the top of the thief zone and its bottom. The calculated volume of cement is used as a reference to determine the actual volume of cement that will be used for the cement job. After making several cement plugs in a certain area, calculations are made to determine the percentage of excess. The percentage of excess can be used to determine the suitable volume of cement to avoid loss of cement in the coverage of non-thief zones, in addition to drilling longer distances of cement.

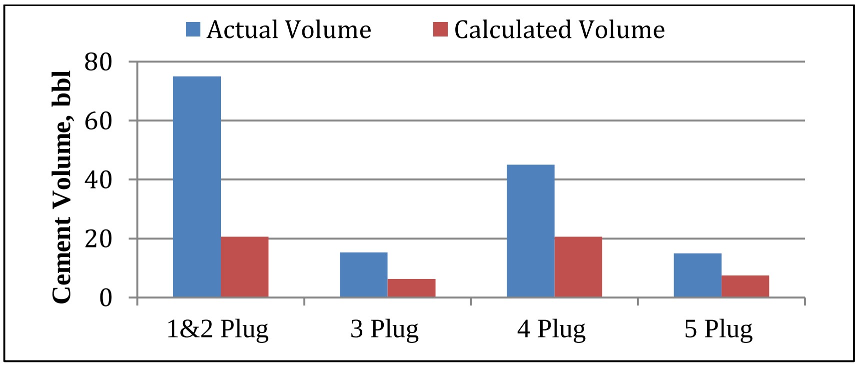

Figure 10 Actual and Calculated Volume of Cement for Well V33

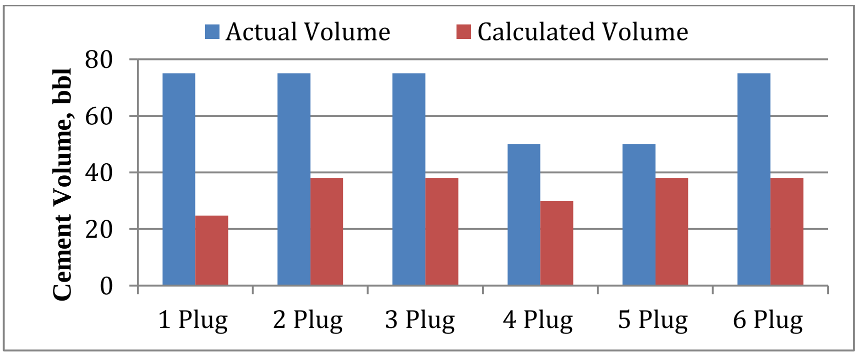

Figure 11 Actual and Calculated Volume of Cement for Well V36

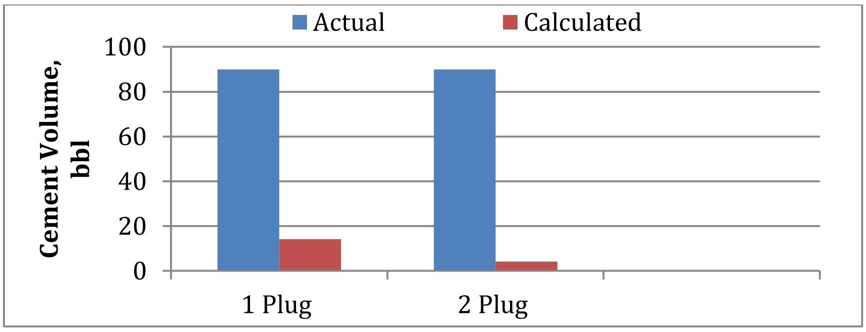

Figure 12 Actual and Calculated Volume of Cement for Well V39

5.8 Cement Volume Distribution in Well.

This section will show the distribution of the cement used to cure losses. After the setting of the cement plug inside the hole, the cement volume is divided into two principal volumes which are the volume of cement absorbed by thief formation and the volume of cement consolidated inside the hole which is also divided into two volumes which are volume of cement consolidated within the interval of thief formation and the volume of cement consolidated above and/or below the thief zone interval. Figure 13 shows the percentage of each volume for the three wells.

6. Conclusion

The problem of drilling fluid loss affects the drilling and constructing of oil wells negatively because it increases costs by increasing rig time, creating additional mud volumes, and using expensive materials like LCM and cement to repair the losses. During roughly 13% to 32% of the construction period, the three wells had a 12¼" hole due to the loss of circulation. On the first attempt, obtaining effective cement plugs is challenging; normally, several attempts are required.

In this study, LCM failed to cure or reduce the losses, indicating that the thief formation contains enormous cavernous fractures. The FACHA DOLOMITE formation experienced the majority of the losses, while some losses also occurred in the upper portion of the KHEIR LIMESTONE formation.

The number of cement plugs for each well depends on several factors such as the number of cement barrels per plug, the number of cement plug failures after continuing drilling, and the length of losses interval.

The total number of cement barrels used for each well is not related to the number of plugs in the same well (e.g. V39 and V33). Because the number of cement plugs as stated depends on several factors and the most important factor is the number of cement barrels per plug, which is why an increase of cement barrels per plug is observed from older wells (V33) to newer wells (V39).

References

[1] Adam, B. Keith, M. Martin, C. and F.S. Young (1991). Applied Drilling Engineering, Second Printing, United State of America: Society of Petroleum Engineering.

[2] Pennwell Corpration, Pennwell Publishing Company(2006). Oil and Gas Journal Databook, 2005 Edition, United States: Pennwell Corporation.
[3] Larry W. Lake (2007). Petroleum Engineering Handbook, Volume II, United States of America: Society of Petroleum Engineers.
[4] Don Hallett (2002). Petroleum Geology of Libya, 1st Edition, United Kingdom: Elsevier.
[5] Erik B.Nelson and Dominique Guillot (2006). Well Cementing, 2nd Edition, United state of America: Schlumberger.
[6] Miranda, C.R.; Oliveira, J.L.; Cavalcante, G.M.S.; d' Almeida, A.R.; Pereira, R.F.L.; Santos, R.L.L.; Surmas, R (2017). Materials for controlling severe lost circulation-laboratory evaluation. SPE-185582-MS was Presented at SPE Latin America and Caribbean Petroleum Engineering Conference, 17–19 May, Buenos Aires, Argentina.
[7] Lavrov, A(2016). Lost Circulation Mechanisms and Solutions. Gulf Professional Publishing is an imprint of Elsevier, Amsterdam
[8] Ramasamy, J.; Amanullah, M.(2017). Novel fibrous lost circulation materials derived from deceased date tree waste. SPE-187989-MS was Presented at SPE Kingdom of Saudi Arabia Annual Technical Symposium and Exhibition, 24–27 Apr, Dammam, Saudi Arabia.
[9] Al-Hameedi, A.T.T.; Alkinani, H.H.; Dunn-Norman, S.; Flori, R.E.; Hilgedick, S.A.; Amer, A.S.; & Alsaba, M.T. (2018). Using machine learning to predict lost circulation in the Rumaila field, Iraq. SPE-191933-MS was Presented at SPE Asia Pacific Oil and Gas Conference and Exhibition, 23–25 Oct, Brisbane, Australia.
[10] Fidan, E., Babadagli, T., and E. Kuru. (2004)."Use of Cement As Lost Circulation Material - Field Case Studies." Paper presented at the IADC/SPE Asia Pacific Drilling Technology Conference and Exhibition, Kuala Lumpur, Malaysia.