Journal of Engineering Sciences and Information Technology (JESIT) • Vol 7, Issue 3 (2023) • P: 53 - 44
https://journals.ajsrp.com/index.php/jesit
ISSN: 2522-3321(Online) • ISSN: 2522-3321(Print)

Analysis of the Lost Circulation process for development of drilling operations in Al-Omar oil field – Syria

Eng. Tareq Ali Farid
School of Petroleum Engineering | Yangtze University | China

Received: 28/05/2023
Revised: 09/06/2023
Accepted: 24/06/2023
Published: 30/09/2023

* Corresponding author: tariq1.farid2@gmail.com

Citation: Farid, T. A. (2023). Analysis of the Lost Circulation process for development of drilling operations in Al-Omar oil field – Syria. *Journal of engineering sciences and information technology, 7*(3), 44 – 53. https://doi.org/10.26389/AJSRP.F280523

Abstract: One of the major challenges confronting the oil and gas industries worldwide is lost circulation, which results in significant amounts of drilling non-productive time. Drilling fluid loss may result in additional drilling issues such as stuck pipe, borehole instability, or a potential well control event.

Al-Omar field in Syria is one of the world's largest oil fields. When drilling through the Shiranish formation, wells in this field are highly susceptible to lost circulation problems. The lost circulation processes in Al-Omar Oil field are close to complete failure due to leakage. This issue is important in field development operations and is given great attention.

If the process is carried out according to the correct course, there is expected to be a significant decrease in Non-Productive Time (NPT) resulting from the loss. On the other hand, this paper will consider the cost of remedy processes and the NPT relating to the remedy method used. The loss in the Shiranish layer comes from more than 700 oil wells drilled in Syria and is discovered using field sources and various engineering reports. Remedy processes were divided according to the field data into three losses: (1) partial loss, (2) severe losses, and (3) complete losses.

In this paper, we use economic forecasts that are considered significant from an economic point of view when setting remedy processes. In addition, we employ the incoming probabilities method and remedy the costs of lost circulation in Al-Omar field in Syria. We perform hundreds of remedies on the three types of losses, calculate the Expected Monetary Value (EMVs) in all operations to reduce NPT and high costs, and choose the least costly method to process EMV that we can apply correctly and practically and is acceptable to remedy all types of losses. And if the losses continue after using the proposed solutions, we can suggest some changes in the design of the well to prevent losses.

The methods used in dealing with the problem of lost circulation are some of the most significant challenges we face at Al-Omar oil field in Syria, and as a result, the data analysis process provides a clear path for the Syrian fields. It can also be used in other similar formations in the Middle East. It also applies to configurations with properties identical to Al-Omar oil field.

Keywords: Oil field drilling - Lost Circulation process - Al-Omar oil field – Syria.

تحليل عملية التدوير الضائع لتطوير عمليات الحفر في حقل العمر النفطي – سوريا

م. طارق علي فريد
كلية هندسة البترول | جامعة يانغتسي | الصين

المستخلص: تعتبر أحد أهم التحديات الرئيسية التي تواجه صناعات النفط والغاز حول العالم هو التدوير الضائع، والذي ينتج عنه كميات كبيرة من وقت الحفر غير المنتج. قد يؤدي فقدان سوائل الحفر إلى مشاكل حفر إضافية مثل الأنابيب العالقة أو عدم استقرار البئر أو حدث محتمل للتحكم في البئر.

حقل العمر في سوريا من أكبر حقول النفط في العالم. عند الحفر في تكوين شيرانيش، تكون الآبار الموجودة في هذا المجال معرضة بشدة لمشاكل التدوير الضائعة. عمليات التدوير المفقودة في حقل العمر النفطي الذي يقترب من فشل كامل للبئر بسبب التسرب. هذه قضية مهمة في عمليات التطوير الميداني وتحظى باهتمام كبير.

إذا تم تنفيذ العملية وفقًا للمسار الصحيح، فمن المتوقع أن يكون هناك انخفاض كبير في الوقت غير الإنتاجي (NPT) الناتج عن الخسارة. من ناحية أخرى، ستنظر هذه الورقة في تكلفة عمليات العلاج وكذلك في الوقت الغير الانتاجي المتعلقة بطريقة العلاج المستخدمة. وتأتي الخسارة في طبقة الشيرانش من أكثر من 700 بئر نفط تم حفرها في سوريا ويتم اكتشافها باستخدام مصادر ميدانية وتقارير هندسية مختلفة. تم تقسيم العمليات العلاجية وفقًا للبيانات الميدانية إلى ثلاث خسائر: (1) خسارة جزئية، (2) خسائر فادحة، و (3) خسائر كاملة.

في هذه الورقة، نستخدم التنبؤات الاقتصادية التي تعتبر مهمة من الناحية الاقتصادية عند تحديد عمليات العلاج. بالإضافة إلى ذلك نستخدم طريقة الاحتمالات الواردة وعلاج تكاليف التدوير الضائع في حقل العمر في سوريا. نقوم بإجراء مئات العلاجات على الأنواع الثلاثة للخسائر، ونحسب القيمة النقدية المتوقعة (EMVs) في جميع العمليات لتقليل الوقت الغير انتاجي والتكاليف المرتفعة، واختيار الطريقة الأقل تكلفة لمعالجة القيمة النقدية المتوقعة (EMV) التي يمكننا تطبيقها بشكل صحيح وعملي ومقبول من قبل علاج جميع أنواع الخسائر. وإذا استمرت الخسائر بعد استخدام الحلول المقترحة، فيمكننا اقتراح بعض التغييرات في تصميم البئر لمنع الخسائر.

تعتبر الأساليب المتبعة في معالجة مشكلة التدوير الضائع من أهم التحديات التي نواجهها في حقل العمر النفطي في سوريا، ونتيجة لذلك فإن عملية تحليل البيانات توفر مسارًا واضحًا في حقول النفط السورية. حيث يمكن تطبيقه في تشكيلات أخرى مماثلة في الشرق الأوسط. كما أنها قابلة للتطبيق على التكوينات ذات الخصائص المشابهة لتلك الموجودة في حقل العمر النفطي.

الكلمات المفتاحية: عملية التدوير الضائع - حفر حقول النفط - حقل العمر النفطي – سوريا.

Introduction

Drilling fluids are critical components of the drilling process in the oil and gas industry. Drilling fluids, also known as drilling mud, are designed to cool and lubricate the drill bit, transport moves to the surface, stabilize the borehole, and prevent fluid loss into the drilled formation. However, fluid loss has been a major challenge during the drilling process in Middle Eastern reservoirs, resulting in significant economic losses and sometimes catastrophic environmental consequences.

Drilling fluids are an expensive component of oil and gas well drilling. Drilling fluids are circulated through the drill string and drill bit to remove cuttings from the borehole and enable drill bit performance. Drilling mud is specially formulated to form a thin coating on the borehole wall known as a mud cake, which limits fluid losses to previously drilled and exposed formations in the borehole as the drill bit advances deeper and deeper.

Lost circulation, or lost returns, is "the partial or total loss of circulating fluid from the wellbore to the formation." The formation is caused by losing whole fluid, not just filtrate. Natural or induced losses can result in losses ranging from a few barrels per hour to hundreds of barrels in minutes. In terms of rig time and safety, lost circulation is one of the most expensive aspects of drilling. Uncontrolled circulation loss can lead to a dangerous pressure control situation and loss of the well.

DTA and EMV have been used to assess the value of information derived from the exploration and development of petroleum assets (Ibarra et al., 2017). Usually, both decision tree analysis (DTA) and (EMV) are used in petroleum industry operations to help the decision-making process Heinze (1995). Therefore, it can be used to select the best method to complete the fields through lifting methods since they contain large proportions of H_2O and CO_2.

There are some differences between researchers and those interested in this field (Schulze et al., 2012; Erdogan et al., 2001)). Many researchers have found different results from using these methods. Gu et al. 2005, used DTA and extracted data to determine the relationship between stress fracturing and load in environmental conditions. And Xu, 2013 evaluated the value of the North Sea well drilling project using random simulation and DTA.

Shiranish is the only formation with losses in Syria's oil fields. The upper part of this formation is composed of limestone and is found at a depth of 2932 meters.

Previous studies took economics into account (Al-Hameedi et al. 2017, Alkinani et al. 2017). All remedies used in clay-inducive loss, mixing processes, and additives are described in this study.

The main purpose of this paper is to present a method for selecting the best-lost circulation remedy for the three loss types: partial, severe, and total. Data were collected from over 700 wells drilled through the Shiranish formation in Syrian oil fields. Both the success and failure probability of this method were calculated.

To help us choose the best and most important remedy to remedy the problem of circulation loss, DTA and EMV are used at a lower cost, thus dealing with expectations and economic criteria for decision-making.

Fig(1) Al-Omar filed – Syria

Research Methodology

Data from over 700 wells was collected from various sources and reports, and the treatments were classified as partial, severe, or complete losses. This paper recommends the best-lost circulation treatment for each type of loss using probabilities, expected monetary value (EMV), and decision tree analysis (DTA). Using mathematical equation (1), we can find the value of EMV (Dr. Kelkar, 2013).

$$\text{EMV}= \sum_{i=1}^{n} pi\,(NPV) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .1$$

(n): The number of possible outcomes.

(NPV): The net score value for *i*

(pi): Predict the outcome (probability) for *i*.

We consider the total calculation of the three types of loss separately because the pumping process and intake and output will be completely different. This gives us a completely different NPT with different depths. We do the calculation process for each formation separately. Normally, there is a difference in the losses and mud for each formation after the remedies. Since some remedies must be applied more than once, there is a difference between successful and unsuccessful remedies in terms of cost. As a result, given that this analysis is used for each well and not for each remedy, this frequency is in the total cost only. When calculating the probability of success if the remedy was used more than once (in the same well), if successful, then it is considered as a single successful remedy because the probability is calculated for each well and not for each remedy (Alkinani et al., 2018c). All possibilities (expectations) were considered to select the best solution for each of the three types of loss (partial, severe, or complete) (Alkinani et al., 2018):

The analysis takes into account all treatment scenarios to determine the most favorable scenario for each type of mud loss (partial, severe, and complete) under the following assumptions (Alkinani et al., 2018c):

- The sequence of treatments is critical.
- It is not permitted to repeat the treatments.
- If partial losses occur, three partial losses treatments are assumed to be used; if that fails, three severe losses treatments are assumed to be used. If that doesn't work, three total losses should be used.
- Four severe loss treatments should be used in the event of severe losses. If they fail, five total loss treatments should be used.
- Calculations for using three to eight treatments are considered for total losses.
- If all treatments fail, all processes result in a liner hanger.

The following Equation (Uspensky, 1937) can be used to calculate permutation for all processes:

$$p_k = k\,!/(k-1)! \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

P_k: denotes the number of Processes and k denotes the total number of treatments available (Alkinani et al., 2018c).

Shiranish Formation

In this section, we will explain how to calculate cost and expectations for Sharanish formation concerning the three types of loss (partial, severe, and complete losses).

First: Partial (limited) loss (1-10 m3/hour)

All remedies for partial loss are fed through bottom-hole assembly (BHA). There is no need for an open-end drill-pipe (OEDP) out-and-out process. As a result, there is a non-productive time (NPT). The following equations can be used to calculate the final cost only for success or failure for partial (limited) losses:

$$\textbf{Total cost (\$) = Average Treatment cost (\$) + Total NPT(\$)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots .3$$

$$\textbf{a verger treatment cost (\$)= treatment cost(} \$/m^3) \textbf{ (Avol } m^3) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .4$$

$$\text{Total (NPT) (\$)= thickening time (hour) * rig cost} \left[\frac{\$}{hr}\right] \ldots\ldots 5$$

$$\text{The ultimate cost of success (\$)} = \frac{\textit{Total cost}*\textit{number of successful treatment Usage}}{\textit{successful wells}} \ldots\ldots 6$$

$$\text{Final cost of failure (\$)}= \frac{\textit{Total cost}*\textit{number of failure treatment Usage}}{\textit{successful wells}} \ldots\ldots 7$$

It should be noted that the cost of applied remedies that have not been proven successful will differ from the cost of successful remedies. This is because some remedies must be repeated more than once to be effective (Mathematics Equation 6 shows how to compute the total cost of a success-and-failure process, and so does Equation 7. The following mathematical equations can be used to calculate both the likelihood of success and failure for the three types of loss (partial, severe, and total) (Alkinani et al., 2018c):

$$P_s = \frac{\textit{successful wells for specific treatment}}{\textit{total successful wells for specific treatment}} \ldots\ldots 8$$

$$P_f = (1 - P_s) \ldots\ldots 9$$

P_S & P_f are the success and failure Likelihoods.

Second: severe (large) losses (> 15 m3 / hour) and complete losses (without return)

We classify severe loss remedies into two types:

1. Infusion of remedies available via BHA, especially partial loss remedies.
2. Pumping with OEDP (to prevent any orifices from getting clogged) could result in tripping out of the orifice, removing the BHA, and possibly tripping again.

In the second method, NPT will occur due to tripping in and out of the hole. The final cost of heavy loss remedies pumped through BHA is the same method of calculating the final cost of partial losses (equations 3-7). We can calculate the final cost from mathematical equations 3-7 as we calculate the partial cost pumped by BHA. And because the calculation process for the OEDP pumped is completely different because three of them will have additional NPT due to trips in and out of the hole. (Alkinani et al., 2018). OEDP-pumped remedies differ depending on whether the remedy is applied before or after any other remedy. This is because tripping in and out will be required when only the first remedy is applied; When we have the OEDP in place, there will be no need for an in-and-out trip for any second remedy. The following equations compute the final total cost of OEDP-pumped severe loss remedies assuming the remedy is initially applied. Due to in-and-out trips, NPT is to be taken into account:

$$\text{(Total cost \$) =average Treatment cost + total NPT} \ldots\ldots 10$$

$$\text{Average Treatment cost (\$) = Treatment cost (} \$/m^3 \text{) (Avol } m^3 \text{)} \ldots\ldots 11$$

$$\text{Total NPT (\$)} = \left[\text{Thickening Time (hr)} + \text{Trip in and out (hr)} \right] * \text{Rig cost} \left(\frac{\$}{hr}\right) \quad \ldots\ldots 12$$

$$\text{Cost of successful Repeated treatment (\$)} = \left[\text{Average treatment cost (\$)} + \text{thickening Time (hr)} * \text{Rig cost} \left(\frac{\$}{hr}\right) \right] * \text{number of successful Usage} \quad \ldots\ldots 13$$

$$\text{Cost of failed Repeated treatment (\$)} = \left[\text{Average treatment cost (\$)} + \text{Thickening Time (hr)} * \text{Rig cost} \left(\frac{\$}{hr}\right) \right] * \text{number of failure Usage} \quad \ldots\ldots 14$$

$$\text{Final cost of success (\$)} = \frac{Total\ cost * successful\ wells + cost\ Repeated\ Treatment}{successful\ wells} \quad \ldots\ldots 15$$

$$\text{Final cost of Failure (\$)} = \frac{Total\ cost * \text{Failure}\ wells + costof\ \text{Failure}\ Repeated\ Treatment}{\text{Failure}\ wells} \quad \ldots\ldots 16$$

To avoid orifice clogging, we pump all available remedies to total loss by OEDP. The final cost of the total losses can be calculated through equations 10-16.

Discussions with the result

Figure (2) shows only examples of the three types of loss (partial, severe, and complete) top twenty remedies due to many remedy processes. As figure 4 shows 3 to 8 processes to remedy total losses; Obviously, there is no significant difference between the use of three and eight remedies. As a result, it is preferable to use eight remedies for total losses before using the liner hanger.

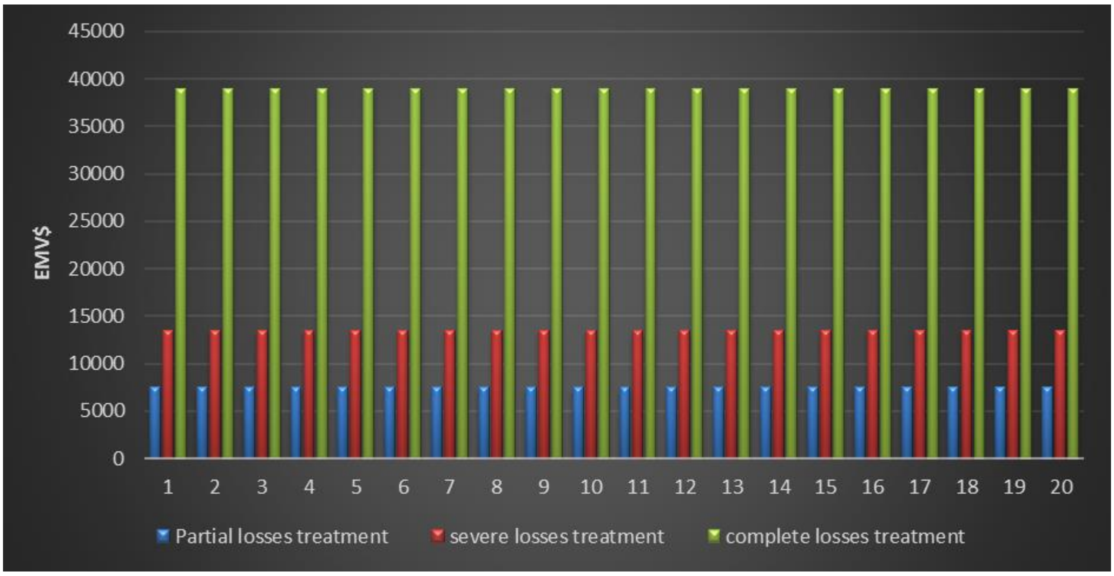


Fig (2) Treatments processes for Partial Losses (the Shiranish Formation)

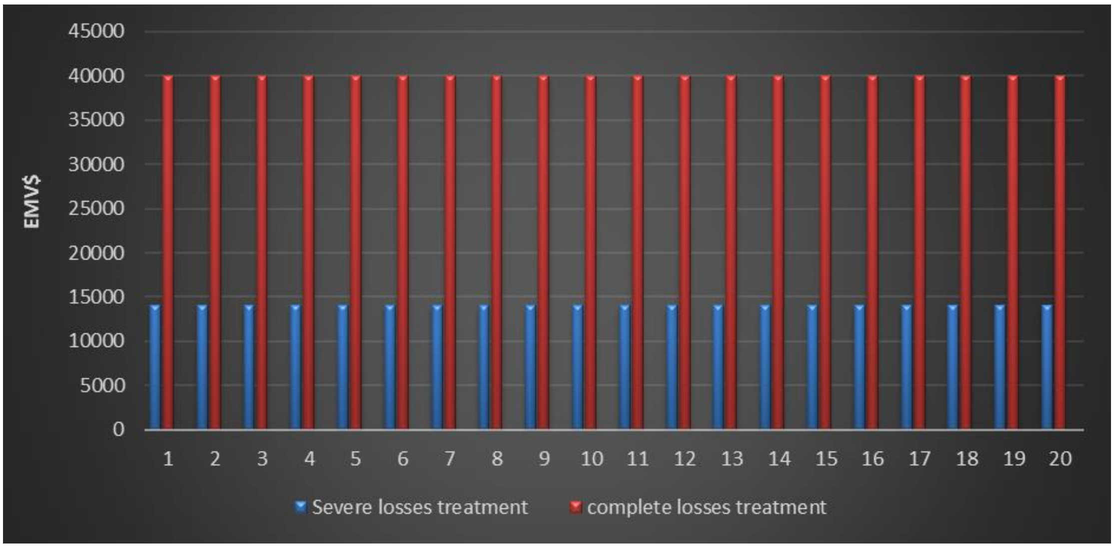


Fig (3) Treatments processes for Severe Losses (the Shiranish Formation)

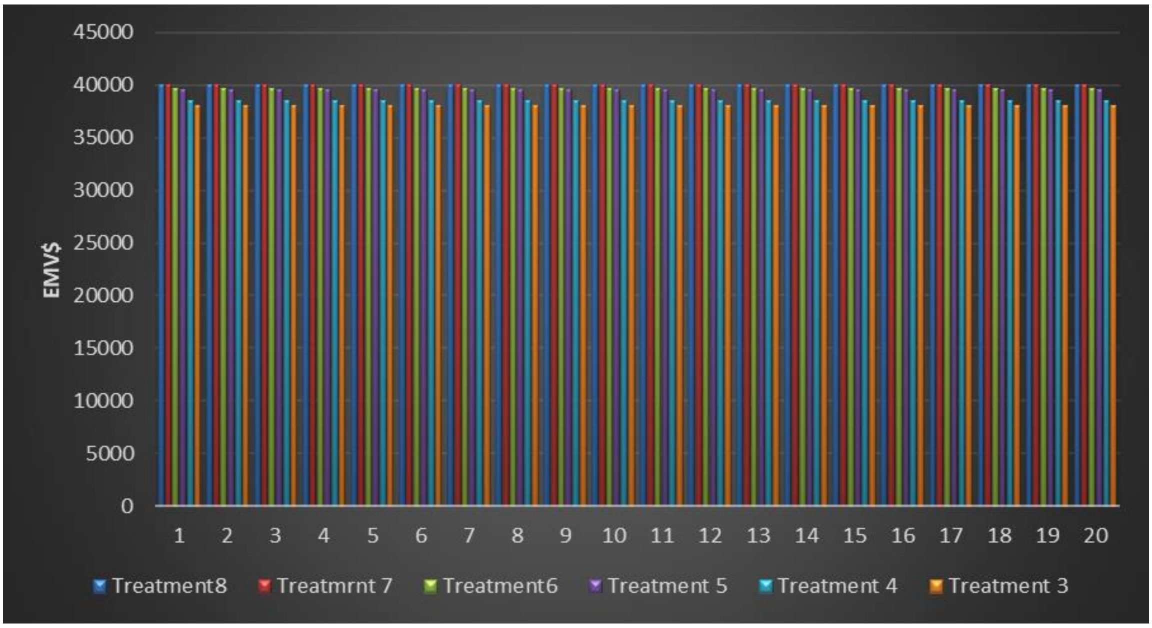
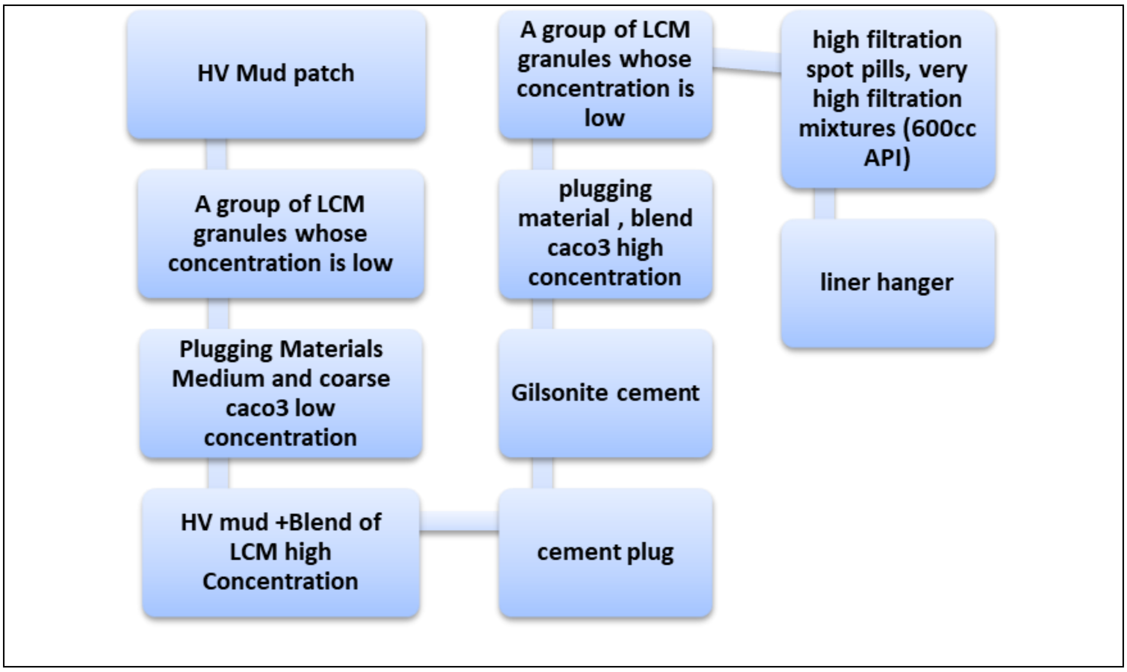
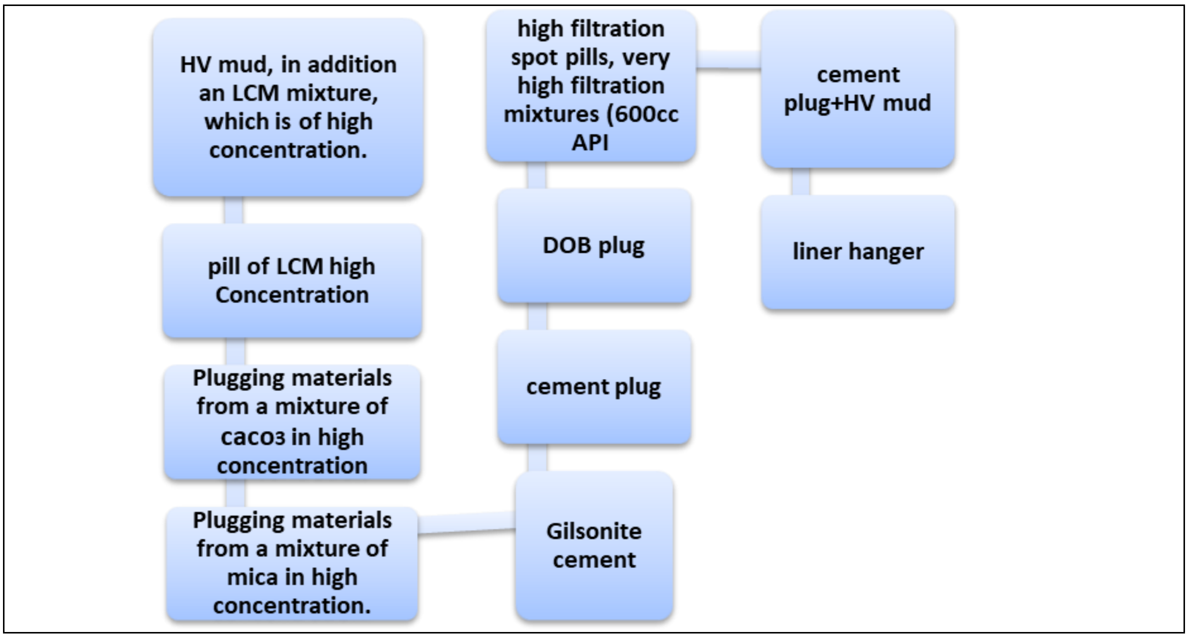


Fig (4) Treatments processes for Complete Losses (the Shiraishi Formation).

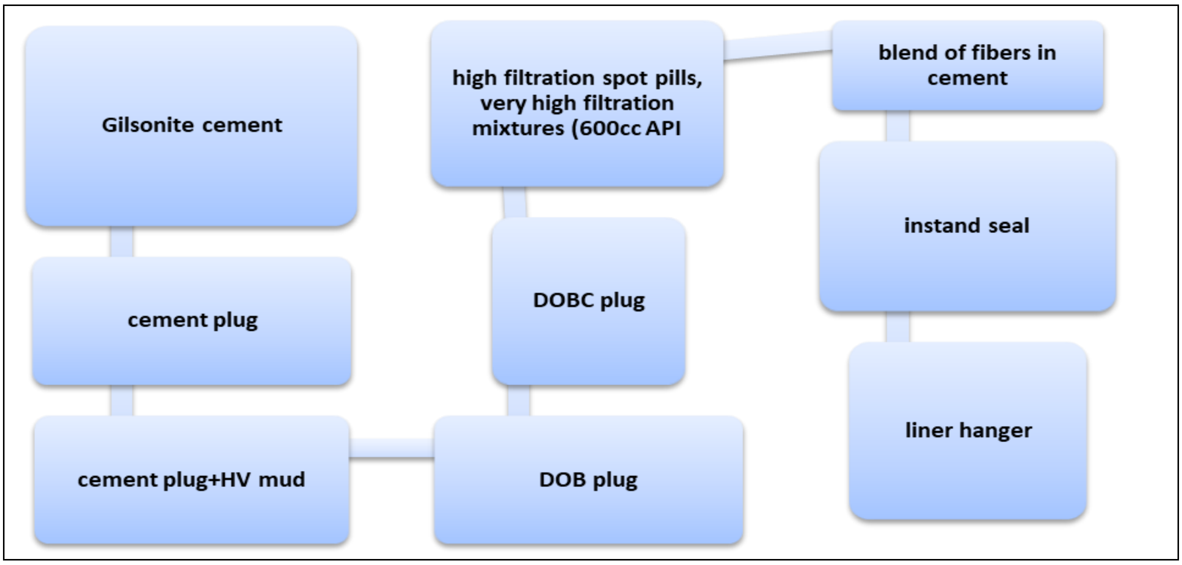
Figure 5 depicts partial mud loss treatment strategies for the al Shiraishi formation. Figure 6 depicts the treatment processes for severe mud losses in the Alshiranish formation. Finally, Figure 7 depicts complete mud loss treatment strategies for the Alshiranish formation. All treatment strategies result in a liner hanger.



Fig(5)Partial Losses Treatments processes (the al Shiranish Formation)



Fig(6)Severe Losses Treatments processes (the al Shiranish Formation)



Fig(7)Complete Losses Treatments processes (the al Shiranish Formation)

Suggested solutions to Lost Circulation in Al-Omar Oil Fields- Syria. Suggested solutions to the lost circulation problem will be presented in this section. Specifically, changing the good design to isolate the loss formations and avoid unfavorable consequences caused by abnormal transitional zones such as H2S flow and collapse issues. Figure 8 depicts the well design and lithology in the oil fields of Syria. Al Shiranish is one formation vulnerable to lost circulations (highlighted in yellow). Circulation losses in the al Shiraishi can range from partial to complete.

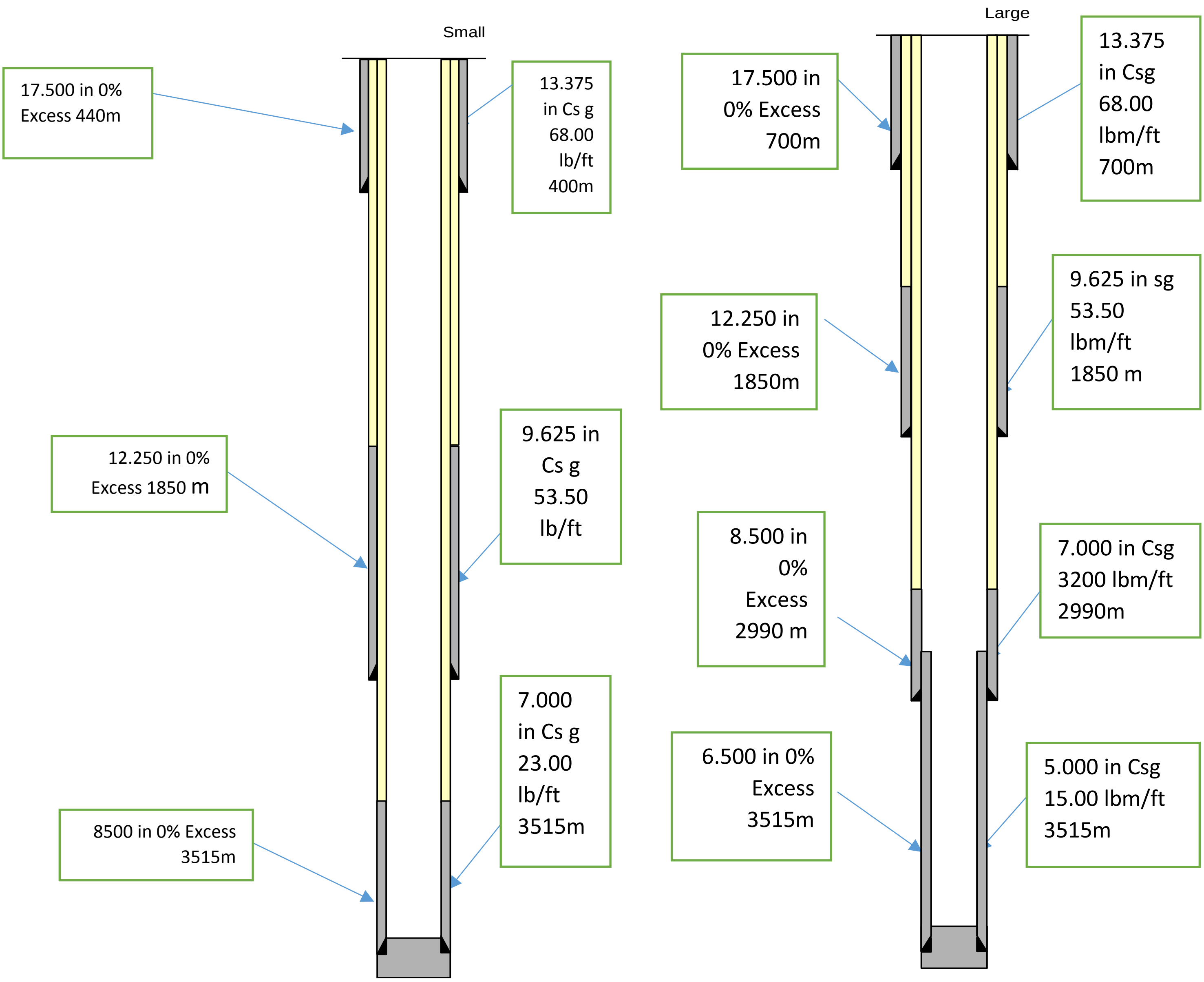
Once the al Shiraishi formation is successfully drilled, there will be two abnormal transitional formations, Dhiban and Euphrates, both of which have H2S flow. The mud weight must sometimes be increased to avoid H2S from the Dhiban and Euphrates formations. On the other hand, the al Shiraishi formation is a weak formation that remains in the same open-hole section when drilling.Formations of the Dhiban and Euphrates. Increasing mud weight to avoid H2S can result in a loss of circulation in the al Shiraishi formation.

Mud weight	Toler. (+/-m)	Formation	Lithology	problems	Depth (m)
9.20	9	Lower Fars	Sand and pebble	High gel strength sand content and filtration	357.0
9.20	5	Lower Fars Salt	Argillaceous limestone	High viscosity and balling	833.0
9.60	10	Lower Fars TZC	Sand and pebble	Wash pipe and corrosion	1032.0
9.80	10	Jeribe	Dolomite	High contamination of ca++	1091.0
10.00	12	Dhiban	Anhydrite	H2s flow	1181.0
10.00	18	Euphrates	Dolomite	H2s flow	1243.0
10.00	11	Chilou	Shale	Low penetration	1377.0
10.00	8	Jaddala	Argillaceous limestone	Shale sloughing	1705.0
7.60	10	Aaliji	Limestone	Stuck pipe and low penetration rate	2342.0
7.60	16	Shiraishi	Limestone	Lost circulation because of nature fracture	2932.0
7.60	100	Erek	Shale	Kick because high pressure	3697.0
7.60	100	Derro	Limestone	Shale sloughing and collapse	3725.0
7.60	100	Main N-bound fault	Limestone	Formation hardness is high	3747.0
9.50	60	BKU/Judea Carb.	Limestone	Abnormal pressure	3822.0
9.50	60	RUU	Limestone	Low penetration	3868.0
9.50	70	RUL	Shale	Shale sloughing	3913.0
9.50	90	Mulussa F1	Limestone	struck pipe	4033.0
9.50	100	Mulussa F2	Limestone	Low penetration rate	4173.0
9.50		OOWC	Shale	stuck pipe	4272.0
9.50	100	Mulussa F3	Limestone	Low penetration	4333.0

Fig (8) Lithology in Al-Omar oil field - Syria (Euphrates Oil Company)

Figure 9 depicts the used casing design and the new (suggested) design. The new well design will include more casing points to isolate the loss formations and avoid unfavorable consequences caused by abnormal transitional zones, such as H2S flow and collapse issues. The cost of drilling wells in Syria oil fields may be reduced by changing the good design due to decreased NPT associated with mud losses and other drilling problems. Furthermore, the wells will be drilled more safely because the H2S, gas cut and collapse zones will be better controlled. A comprehensive economic evaluation of the new casing design should be performed to ensure it is more cost-effective than the old design.

used casing design **new (suggested) design.**



Fig(9) used casing design and a new (suggested) design

Conclusions

Loss of circulation is a complex problem in all Syria oil fields in general and Al-Omar in particular. We have great difficulty deciding what remedy to apply to address the loss. Cost is a significant factor that must be calculated when carrying out remedies. In this paper, data from more than 700 wells (drilled) in Syria oil fields were analyzed to develop a method to address the most severe circulation loss for each type of mud loss while taking into account keeping costs down.

The main goal is to save both money and time. Based on the results, the following was concluded:

- Considering the economic aspect and the possibilities which distinguish this paper from others.
- Providing a method (a drawing) on a flowchart of the three types of loss in the Shiranish formation that deals with the lowest electromagnetic efficiency is practically applicable to remedy loss types.

- Figure (9) shows that the proposed design to treat loss and NPT should also be studied by specialists more accurately to ensure its effectiveness.
- Should data be available, we can apply this study in the Middle East oil fields or the whole world.

Acknowledgment

This paper's author thanks Euphrates Oil Company's management for giving me all the data I need for this research.

Nomenclature

- OED P= Open End Drill Pipe
- kg/m^3 = Kilograms per Cubed
- kg = Kilograms
- bbl. = barrels
- DOB: Diesel Oil Bentonite
- DOB= Diesel Oil Bentonite
- NPT = Non-Productive Time
- BHA = Bottom Hole Assembly
- ft = foot
- LOT = Leak-Off Test
- TOC = Top Of Cement
- LCM = Lost Circulation Material
- DOBC= Diesel Oil Bentonite Cement
- NPV = Net present value
- EMV=Expected Monetary Value
- $= Dollars
- ECD = Equivalent Circulation Density

References

1- Euphrates Oil Company. With Various Daily Reports, Final Reports, and Tests from 2008 to 2017. Several Drilled Wells, in Al-Omar Oil Fields- Syria.

2- Slaheddine Kefi, Jesse C. Lee, Nikhil Dilip Shindgikar, Chrystel Brunet-Campbus, Benoit Vidick, Nelson Ivan Diaz. IADC/SPE 133735 SPE Paper "Optimizing in Four Steps Composite Lost-Circulation Pills Without Knowing Loss Zone Width". Presented at IADC/SPE Asia Pacific Drilling Technology Conference and Exhibition in Ho Chi Minh City, Vietnam 1-3 November 2010.

3- Soroush, H., and Sampaio, J. H. B. 2006. Investigation into Strengthening Methods for Stabilizing Wellbores in Fractured Formations. Paper SPE 101802 presented at the SPE Annual Technical Conference and Exhibition Held in San Antonio, Texas, USA, 24-27 September.

4- Wang, H. "Is It Possible to Efficiently Form A Strong Seal inside Subterranean Openings without Knowing Their Shape and Size?". AADE-11-NTCE-25, AADE National Technical Conference and Exhibition, Houston, USA, 8-9 April 2011.

5- Al-Hameedi, A. T. T., Dunn-Norman, S., Alkinani, H. H., Flori, R. E., Torgashov, E. V., Hilgedick, S. A., & Almohammedawi, M. M. (2017b, October 17). Preventing, Mitigating, or Stopping Lost Circulation in Dammam Formation, South Rumaila Field, Iraq; Requires Engineering Solutions, the Best Treatments Strategies, and Economic Evaluation Analysis. Society of Petroleum Engineers. doi:10.2118/186180-MS.

6- Cheldi, T. Cavaasi, P., Lazzari, L., & Pezzotta, L. (1997, January 1). Use Of Decision Tree Analysis And Montecarlo Simulation For Downhole Material Selection. NACE International. Darley, H.C., Gray, G.R., 1988. Composition and Properties of Drilling and Completion Fluids, sixth ed., 720. Gulf Professional Publishing Jassim, S. Z. and Goff, J. C. 2006. Geology of Iraq. Prague: Dolin. ISBN 978-8070282878.