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Analysis of Stuck Pipe Incidents in Khabaz Field

Nazaneen Said Amin[a] and Ayad A.Alhaleem[b]

[a]Drilling Department /North Oil Company
[b]Petroleum Engineering Department/ College of Engineering/ University of Baghdad

Abstract

There are many events which causes nonproductive time (NPT) in the drilling industry. The mostly effective in this NPT is pipe sticking event. A considerable amount of time and resources can be spent in efforts to free a stuck pipe. In addition, Unsuccessful fishing operations results in costly alternatives including side-tracking. The drilling in Khabaz oil field poses many operational challenges among of them stuck pipe , lost circulation, flow of salt water during drilling, and hole caving. Stuck pipe can be considered the quite difficult problem in Khabaz oil field due to associated incidents which lead to NPT activities.

Well Khabaz -34 was selected to study the problem of stuck pipe in this field. An analysis of stuck pipe events was made by using the graphical analysis software Easy View. The results were then discussed to identify the causes of stuck pipe. Finally, recommendation to select proper type /drilling fluid rheology properties, optimize casing seat design to reduce probability of stuck pipe.

Keywords: Khabaz oil field, Easy View

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1- Introduction

One of earliest papers on stuck pipe was discussed causes, prevention, and recovery of stuck pipe, major causes are described as key seating, improper mud control, cuttings, sand, caving, and balling up. Many of the causes and practices are the same ones the industry deals with today **[1]**. British petroleum company achieved 70% reduction in company-wide stuck pipe costs mainly by recognizing the importance of drilling contractor and service company, promoting a rig team approach including training on rig team stuck pipe problem solving, and raising awareness through coordinate worldwide communication program**[2]**. 54% of stuck pipe events analyzed (58 of 108) occurred while tripping and back reaming in Schlumberger's data set[**3]**an increasing in the risk of stuck pipe was observed due to a recent increase in drilling activities, drilling in depleted and higher-risk reservoirs **[4]**.many researchers proposing the use of a statistical method for predicting stuck pipe **[5]**, **[6**].

2- Analysis of Stuck Pipe Incidents in Khabaz Oil Field

Khabaz oil field is located in the north east of Iraq at approximately 20 km North West of Kirkuk city. It lies between jambur and bai hassan structures and south west of the baba dome.

The field was discovered in 1955, the first well kz-1 drilled on April 1976 and the last well kz-42 drilled in 2016.

The khabaz structure (tertiary & cretaceous reservoir) consists of an elongated asymmetrical anticline, with15 km length and 5 km width, with a nw-sw axis and faulted mainly on its west flank by reverse.

Many historical wells have been drilled in the khabaz oil field show the general risks faced while drilling include the presence of multiple marly and siltstone formation causes tight hole section, stuck pipe events/ massive salt layers in the saliferous formation which affect wellbore stability **[7]**,lost circulation events that could lead to drop in mud levels (both in the annulus and the casing bore) **[7]**, overpressure formations from 1700 mtop seepage beds to the top of jeribe formation **[8]** as shown in Fig. **1** KHABAZ OIL FIELD PRESSURE PROFILE, flow of salt water, difficulty in maintaining mud properties and difficulty in achieving cement displacement.

H2Scontent in the untreated oil from the tertiary reservoirs is 14ppm; in mauddud, it is 200 – 1628ppm; and in shuaiba the content is 218– 880ppm **[8]**[8] .

The challenges that have cause stuck pipe incidence, among other non-productive activates, we should analysis and concentrate on this problem trying to prevent or to reduce it.

General stratigraphic for Khabaz oil field **[7]** is given in Table **1.**

Corresponding Authors: Nazaneen Said Amin, Email: Naz7eng@yahoo.com, Ayad A.Alhaleem, Email: ayadah62@yahoo.com

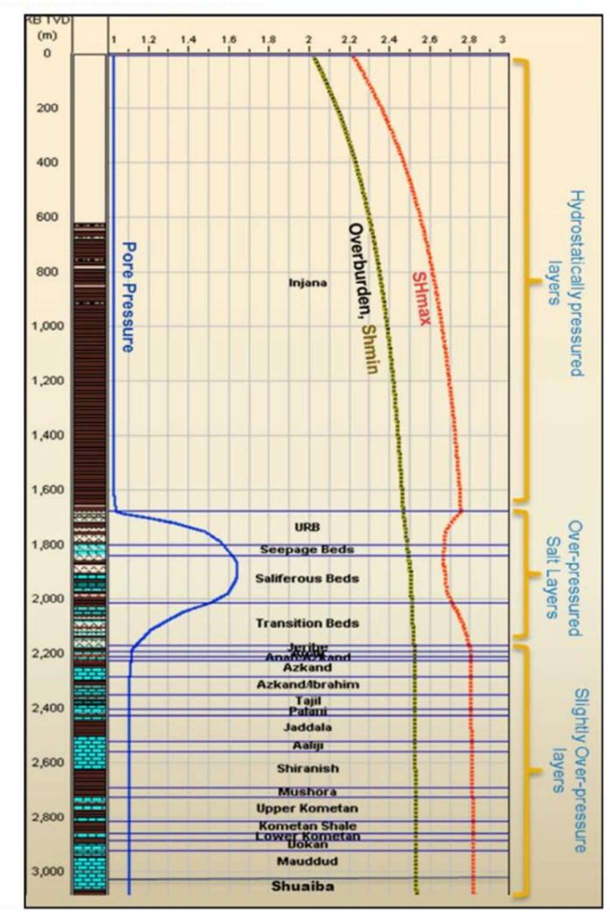

Fig. 1. Khabaz oil Field Pressure Profile

Table 1. General stratigraphic for Khabaz oil field **[7]**

Formation	Expected Top (mater from Ground Level)
Anjana	0
Upper Red Beds	1670
Seepage Beds	1793
Saliferous Beds	1833.5
Transition Beds	2009
Jeribe	2166
Anah	2188
Anah/Azkand	2206
azkand	2222
Azkand/Ibrahim	2282
Tarjil	2346
Palani	2400
Jaddala	2421
Aaliji	2518
Shiranish	2554
Mushorah	2686
Upper Kometan	2721
Kometan Shale	2809
Lower Kometa	2855
Gulneri	2879.5
Dokan	2890
Mauddud	2917
Batiwah	2992
Shuaiba	3102

Note: All depths are measured from Ground Level (GL)

By studying several final well reports of the executed wells in khabaz oil field, it was found that the problem of the stuck pipe incident was occurred in several wells for example well number 7, 31, 34, 35.etc.because of marly formation observed in all beds (cap rocks) that caused loss of time and effort and increasing the cost of the drilling due to fishing operations, and sometimes drilling of the side track. the well number 34 was taken as an example for my study to analysis stuck pipe which occurred at injana formation at 1475m during the drill string was pulled out through the section (1620-1475) m unsuccessful fishing operation the well completed by sidetrack drilling to 9 5/8" casing shoe was set at depth 1840m and trying to cement the casing without successful, then trying to circulate mud with 2500 psi without successful and then 9 5/8" casing was cemented by perforation operation **[7]**.time distribution of stuck pipe events on the drilling the 12 1/4" hole that causing increase NPT as given in Table **2** and compared with Table **3** with actual time without stuck pipe.

Table 2. Time distribution of stuck pipe events on the drilling 2 1/4" hole **[7]**

Hole (in)	Depth stuck (m)	Activity during sticking	NO. days suck	Freed	Days sent fishing	Days spent side track	Total days
	1422	Reaming/ Pullout	1	YES			1
	1475	Drilling/ Pullout	8	NO	47	17	72
12 1/4"	1840	Casing stuck	3	NO	Cemented by perforation spent 15 days		18
	Total nonproductive (NPT) Time						91

Table 3. Time distribution without stuck pipe events on drilling 12 1/4" hole **[7]**

Hole (in)	Active Time(day): Drilling	Dead Time(day): Round Trip& Cir. Run Casing &Cementing Install Well Head & Test Run Tubing &Completion	Total Days
12 1/4"	22	21	43

2.1. Mud Program

The planned program for well khabaz -34 was drilling 12 1/4" hole to depth 2035m that means the injana formation (thickness 1475m), upper red beds (thickness 112m), seepage beds (thickness 31m), saliferous beds (thickness 159m), and transition beds (thickness 153m) will be drilled in the same hole with salt saturated mud (density 2.02 gram/cc).as given in Table **4**.

Table 4. Actual mud program Khabaz -34 **[7]**

Hole Size (in)	Casing Size (in)	Casing Shoe Depth		Mud Weight (grm/cc.)
		Depth (m)	Formation	
17 1/2"	13 3/8"	250	Injana	1.05
12 1/4"	9 5/8"	1840	Upper Red Beds above seepage	1.65*
8 1/2"	7"	2211	Maker T13 above Jeribe	2.02
6"	4 1/2"	2285	Azkand	1.08

*This density is high and caused mud losses followed pipe sticking

2.2. Easy View Diagram and Analysis

The drilling data information during selected stuck pipe events in well khabaz -34 were analyzed using easy view software to recognize and identifying the causes of the stuck pipe and possible solution.

Stuck pipe pro software (stuck pipe analysis) pegasus vertex, inc. (pvi) has developed it to calculate differential sticking force, drag, the free point and back-off force, and the potential chances of a pipe or casing getting stuck during pick-up operations additionally, the stuck mechanical analysis and decision flow charts help users determine stuck-pipe situations and take corresponding measures to free the pipe **[9]**.

The drilling data was recorded using data loggers at the rig site and it has been collected and inputted into easy view software StuckPipePro – Torque and drag model Computational Results

a. Inputted Data in to Easy View Software

The drilling data was recorded from well Khabaz – 34 which drilled by the Iraqi Drilling Company and it has been collected and inputted into Easy View software (**StuckPipePro**) as given following Table **5** and **Table 6** to Analysis of Stuck Pipe Incidents :-

Table 5. Wellbore intervals (from top down): Define the friction factors for each string

Description	I.D. (mm)	MD (m)	Friction Factor (FF)
Casing	320.42	250.0	0.20
Open hole	390.31	1467.0	0.25

Table 6. Formation

Top (m)	Bottom (m)	Pore Pressure (kg/m3)	Fracture (kg/m3)	Permeability (md)	Porosity	Wall cake (mm)
250	398	1028.1	2343.7	0.000	0.070	0.0000
398	923	1028.1	2488.7	0.000	0.070	0.0000
923	1467	1049.6	2489.9	0.000	0.070	0.0000

b. Results from Easy View Software

The diagrams and tables that results from the software have been displayed and described stuck pipe incidents at well khabaz – 34 that occurred during pick up drilling string form 1724m to 1475m through injana formation which consist of soft siltstone, with streaks of marl and anhydrite, it has properties unconsolidated and marly formation. Main drilling potential risks is lost circulation mud, bit balling, and unconsolidated formation.

First hole was drilled and cased to depth 250m to protect the poorly consolidated upper sections, continue drilled the second hole with f.w.b.m. density 1.1 gram/cc to 1707m deviated 2° and continued drilling with s.s.m density 1.65 gram/cc. to depth 1724 m, partial mud losses was occurred, drill string was pulled out with over pull from 1724m to 1475m and it get stuck at depth 1475m.

Margin of over pull the drill string at the surface is 839880 n as shown in Fig. **2**.

So we can see clearly the over pull increasing to the depth 1337.5 m to reach 886392 n and after that depth the value of margin of over pull to be negative value because of stuck pipe effect, stuck forces controlling starts here.

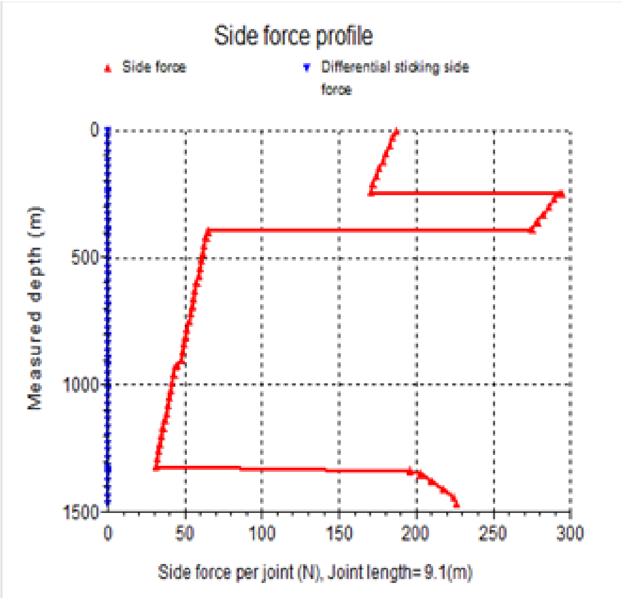

Fig. 2. Margin of over pull

There is no chance of getting stuck pipe as shown in Fig. **3** from the surface to depth 1337.5 m because of the hole was cased to depth 250m and there are no stuck events factors causes from 250-1337.5m.

After that the hole deviated to 2° and partial mud loss resulted from high mud density caused instability the hole and the value of getting stuck increase suddenly to reach to 100% and it is continue to the depth 1475m.

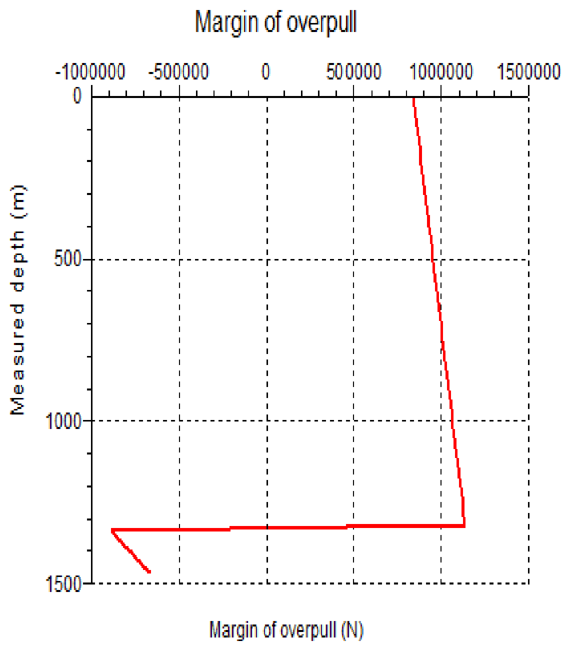

Fig. 3. Chance of getting stuck

We can knew the type of stuck pipe event through side forces profile as shown in Fig. **4**, on the left hand differential sticking side forces value is constant at zero from the surface to depth 1500m confirming no differential sticking pipe force effecting. on the right hand side forces effect on drilling string per joint shows the mechanical force. at depth 250m side force increase sharply to 295n per joint (multiplying number of joints by force) due to 0.3° inclination effect on drilling string and at depth 1337.5m side forces increase to 200-225n per joint. Due to tight section and deviated hole getting mechanical stuck pipe.

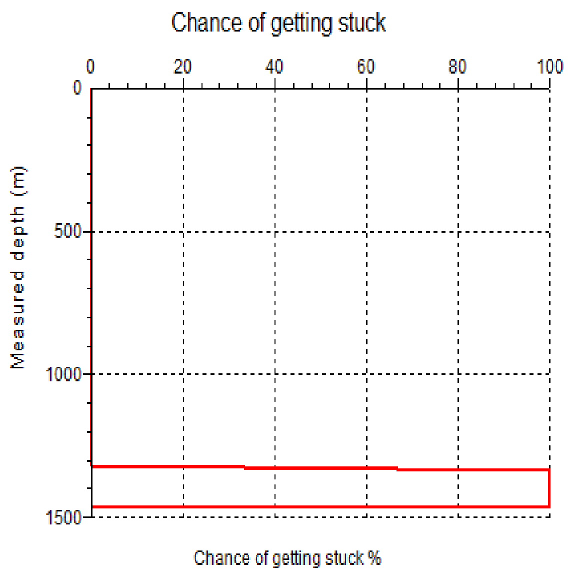

Fig. 4. Side force profile

The axial drag for pick up the drill string and tension limit as shown in Fig. **5** at the surface the maximum allowable load hook -load pick up is 523,901 n, current hook load - pick up is 1186473 n trying to get the string free , the tension limit is 2,210,000 n to avoid string getting parted. the maximum allowable , current load hook -load pick up and decreases due to drug forces effect on drilling string, at the depth 1337.5m , tension limit decreases to zero, and getting stuck. The previous figures are explained by the following Table **7**, Table **8**, Table **9**, and Table **10**.

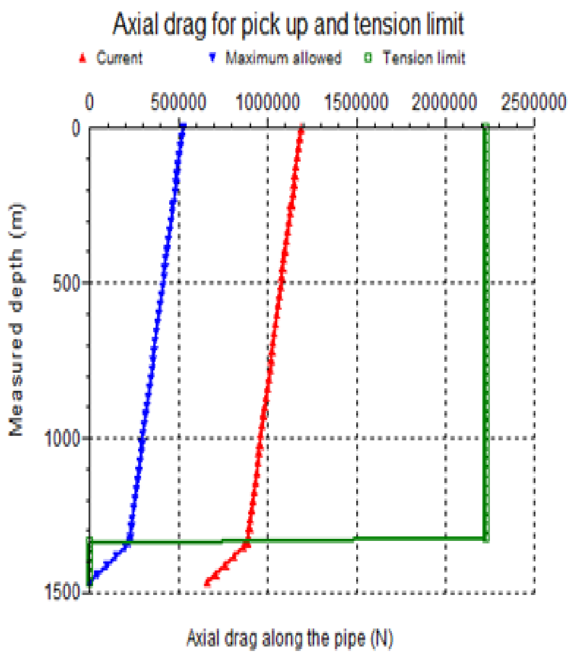

Fig. 5. Axial drag for pick up and tension

Table 7. Summary – Chance of Getting Stuck

Current hook load - Pick up (N)	Maximum allowable hook load - Pick up (N)	Maximum hook load capacity (N)	Allowable margin of over pull (N)	Chance of getting stuck - tensile strength (%)	Chance of getting stuck - maximum hook load capacity (%)
1186473	523901	4448220	886392	100	0

Table 8. Summary – Chance of Getting Stuck at Top of Each Pipe

M.D. (m)	Pipe (OD X ID)	Margin of over pull (N)	Margin of over pull w/o pinning force (N)	Chance of getting stuck (%)
0.0	5 x 4.275984	839880	839953	0
1337.5	8 x 2.812992	886392	-886384	100

M.D. (m)	Axial drag - pick up (N)	Tensile limit(N)	Side F. (N) (per jt.)	Side F. (Diff. stick) (N) (per jt.)	Chance of stuck (%)	Margin of over pull(N)	Contact area (in2/ft.)
1467.0	662530	0	226	0	0	662530	0.00

Table 9. Free point calculation

Distance between 2 pulls (mm)	T1 Pull (N)	T2 Pull (N)	Length of free pipe (m)
105.00	378431	456784	1038.3

Table 10. Back off calculation

80% of Max Torsional Limit at Back-Off Depth in Tension (right turns)	Hydrostatic Pressure at Depth of Back-Off (kPa)	Weight in Mud of Free Length of DP + Block (N)	Weight Indicator Tension at Neutral Point (N)	80% of Rightward Turns for Applying Leftward Twist (left turns)
10	18903.8	262446	262446	8

3- Results , Discussion and Recommended Ideas

The selected proper fluid for each interval after giving the consideration to objectives, risks, technical suitability and cost goals which can be summarized as:

Construct wells suitable for the proposed completion design ,provide hole stability, provide primary control and avoiding stuck pipe.

Depending on the type of layers that consists the upper second hole (injana formation, and upper red beds) it is not necessary to use salt saturated mud (density 1.65 grm/cc.) which caused partial mud losses. the challenge of lost circulation events could lead to drop in mud levels, then cuttings will settled out around the bottom hole assembly, and may the cuttings will act as a packer, and effect losses below them as loss zones may be at low pressure, causing of differential sticking. and also, the presence of multiple marly and silt beds/formations in the absence of control on the formation by the column of drilling fluid causes the instability of the wellbore, mechanical stuck pipe events will be occurred.

When the pressure on transition beds was 3724 psi with safety factor 200 psi, the density of fresh water bentonite will be 1.35 gram/cc that are enough to control the well during drilling operations.

Therefore, an idea can be suggested is to drill the second hole to the depth of 1700 meter (top of upper red beds) with f.w.b.m. density (1.2- 1.35) gram/cc. and always keep the pipe moving as a rule and have enough open hole volume below the bit to accommodate the whole treatment and avoided stuck pipe.

Set second casing shoe at this depth, then third hole drilled with s.s.m. density (1.9- 2.20) gram/cc. to top of jeribe.

Recommendations for mud formulation will be according to what be mentioned in Table **11**.

Depending on the above observations, the well can be redesigned with an explanation of the risks and challenges encountered during drilling.

Table 11. Mud formulations, and recommended properties

Hole Section	17 1/2"	12 ¼"	8 1/2"
Depth to (m) MD	200	1700	2177
Mud Type	Pre-hydrate Bentonite	Pre-hydrate Bentonite /Polymer	Salt Saturated KCL/Polymer
Mud Density (g/cc)	1.05 – 1.10	1.2- 1.32	1.9- 2.20
Funnel Viscosity(sec/qt)	60 - 70	50 – 60	60 -70
Plastic Viscosity (cp)	-	-	-
Yield Point (lb/100 ft2)	25 - 30	20 -25	30 -45
Initial Gel Strength (lb/100 ft2)	8 - 10	7 -9	7 -9
10 min Gel Strength (lb/100 ft2)	10 - 20	10 -18	10 -16
6 RPM *	-	9 -14	9 - 14
API Fluid Loss (cc/30 mins)	N/C	<10 before RIH with casing	< 5
pH	9.0 -10.0	9 - 10	9 - 10
Ca++	< 200 mg/L	< 200 mg/L	< 200 mg/L
Sand %	< 1%	< 1%	< 0.5%
LGS, % vol.	< 7 %	< 7 %	< 7 %
Chloride, mg/l	-	> 15000	>18000
KCL, % -	-	-	3% - 5%
Diesel/Oil, % -	-	-	-
MBT (ppb)	30	15 – 20	<10

4- Conclusion

1- The major factor to avoid risks and problems is selecting the more suitable mud type and mud properties. for example: injana formation interval (surface – 1670m) which consist of soft siltstone; with streaks of marl and upper red beds formation interval (1670 – 1793m) which consist of alternating anhydrite(white, hard, massive),siltstone; (red-brown, soft), limestone markers (r1-r9); (medium hard, pyritic, marly) and marl; (grey-blue, soft) fresh water bentonite (pre-hydrate bentonite) is the suitable mud type to use to avoid mud loss and keep the hole stability

2- Analysis of software results determined the type of stuck pipe which is the mechanical sticking at injana formation, determined free point calculation and back off calculation.

3- analysis of software results show us the elastic and the plastic point for the drilling string and can work safely to apply the over pull and free the pipe under the point 2210000n

4- penetrex which is a mud additive can be used as a good option for preventing bit balling and enhance the drilling rate, at top of lower fars, a treated mud with md (drilling detergent) with 4 gal/100 bbl. (1.0 l/m3) to prevent bit balling and improve drilling rates.

5- Optimizing casing set design to deal with problems separately. Size of 9 5/8" casing should be seat on the upper seepage beds as executed in well khabaz -34 and not as the pervious planning at the upper of jeribe.
6- it is important to keep the drilling solid concentration in mud always under control by using solid control configuration such as desander and desilter

5- Abbreviation

NPT:	nonproductive time
Ppm:	Part per million
Kz:	Khabaz
gram/cc.:	gram/cubic centimeter
In:	Inches
M:	Meter
PVI:	Pegasus Vertex Inc.
FF:	Friction Factor
I.D.:	Inside diameter
MD:	Measure depth
Md:	Millidarcy
S.G.:	Specific gravity
F.W.B.M.:	Fresh water Bentonite Mud
S.S.M.:	Sult saturated mud
Cp:	Centypoice
Lb:	Pound
Psi:	Pound square inch
Gal.:	Gallon
bbl.:	Barrel
Ft:	Feet
RPM:	Round per mint

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تحليل إستعصاء أنابيب الحفر في حقل خباز النفطي

الخلاصة

تواجه عميات حفر الآبارالعديد من المشاكل ومنها مشكلة استعصاء انابيب الحفر التي تعتبر من المشاكل الشائعة جدا في جميع انحاء العالم في صناعة الحفر البترولية مسببة زيادة في الوقت الغير المنتج وخسارة في الوقت والجهد والزيادة في الكلفة نتيجة العمليات الاضافية من التحرير وانتشال انابيب الحفرالملتصقة اضافة الى عمليات الحفر الجانبي في حالة عدم نجاح عمليات الانتشال.

ان الحفر في حقل خباز النفطي يواجه العديد من التحديات والمشاكل من بينها فقدان دورة سائل الحفر ، وتدفق المياه المالحة أثناء الحفر، وتهدم جدار التجويف مسببا استعصاء الانابيب.

لذلك، فإن الحفر في حقل خبار النفطي يكون صعباً جداً بسبب المشاكل التي تؤدي إلى زيادة في الوقت الغير المنتج. لذلك تم اختيارالبئر خباز -34 لدراسة مشكلة استعصاء انابيب الحفر وتم إجراء تحليل البيانات المتوفرة باستخدام برنامج التحاليل الرسومية (stuck pipe pro) يعرض من خلاله الرسوم والجداول والتحاليل بشكل سهل ثم نوقشت النتائج لتحديد أسباب ونوع الأستعصاء . وأخيرا، تمت التوصية لتحديد نوع سائل الحفر المناسب وخصائص سائل الحفر الريولوجية ، وتحسين تصميم إختيار منطقة إجلاس البطانة للحد او تقليل من إحتمال إستعصاء أنابيب الحفر .