Petroleum & Coal
ISSN 1337-7027

Available online at www.vurup.sk/petroleum-coal
Petroleum & Coal 55 (3) 226-233, 2013

OPERATIONAL DECISION MAKING TO PREVENT STUCK-PIPE INCIDENTS IN ONE OF THE IRANIAN GAS FIELD; A CASE STUDY

Hamed Arabi[1], Hosseinali Maghsoudloojafari[2], Morteza Rahimarbabi[3], Reza Khalili[4]

[1]Institute of Petroleum Engineering, College of Engineering, University of Tehran, Tehran, Iran;[2]College of Petroleum & Renewable Energy Engineering, Universiti Teknologi Malaysia (UTM), Skudai, Malaysia;[3]Islamic Azad University of Omidieh, College of Petroleum Engineering;[4]Science and Research Branch Islamic Azad University, Tehran, Iran

Received May 8, 2013, Accepted August 27, 2013

Abstract

The drilling industry is currently investigating different ways of decreasing costs through multitude of enterprising. The stuck pipe is classified as one of the main difficulties because it happens regularly and leads to substantial loss of drilling time. It usually happens in high pressure wells and leads to enormous delays and costs in Iran, every year. Even if distinctive techniques and procedures have been developed to reduce the probability of happening of this phenomenon and these have saved drilling industry millions of dollars, they suffer from exclusive prognostication of this event. Many attempts have been made to determine the reasons of stuck pipe and to outline operating practices that will minimize the incident of the problems. In this paper, according to the potential drilling challenges in each drilling section, we presented the planed drilling fluid and the most efficient decisions to prevent stuck pipe in 23", 16", 12 ¼" and 8 ½" holes during the drilling of a well in the this field. Also the best lost circulation and stuck pipe strategies for each drilling section are expressed.

Keywords: Stuck Pipe; Lost Circulation; Hole Stability; Bottom-Hole Cleaning; Differential Sticking; Mechanical Sticking.

1. Introduction

During the drilling, different problems such as wellbore instability, lost circulation, kicks and blowouts, and stuck pipe are encountered. Stuck pipe occurrences are unplanned incidents requiring drilling companies, work-over companies, and operators to analyze changing wellbore conditions and make best decisions to minimize or moderate the sticking condition. In some situations where the pipe is not released, fishing and even sidetracking should be employed which gives an enormous financial burden on the final cost of constructing the well.

Stuck pipe could cause many problems and accounts for losses of millions of dollars each year in the petroleum industry. Employing the procedures developed, one can manage the parameters involved in the well and reduce the frequency of stuck pipe which leads to [4,7-8,11].

1) Cost reduction for drilling operation (tripping, fishing, etc.)
2) Cost reduction for drilling mud
3) Minimizing time for drilling a well
4) Minimizing damage of BHA and surface equipment

1.1 Typical Pipe-Sticking Problems [1]

There are five typical pipe-sticking problems that occur frequently and lead to considerable loss of drilling time in Iran, every year.

1) Mud Sticking
2) Mechanical Sticking
3) Key-seat Sticking
4) Cement Sticking
5) Differential Sticking
6) Lost-Circulation Sticking

1.2 Drill Pipe Specifications

The drill pipe to be used is 5" DP, 19.5 PPF, S-135 grade with NC-50 connections and also 3 ½" DP, 13.3 ppf, S-135, NC-38.

2. Objectives for 23" Hole Section

The objective Is setting 18 5/8" casing at a depth to isolate Jahrum Formation loss zone and giving sufficient formation strength to drill 16" hole section. The planned setting depth is 20 m TVD into the Ilam Formation, at approximately +1130 m RT.

2.1 Potential Drilling Challenges

Losses: There are Partial losses in the Asmari formation. In Jarhum, Dolomitic limestone with huge caverns of vertical limestone slabs, Partial to total losses as soon as they are encountered and in Sachun equivalent, Limestone with some dolomite stringers and marl, Partial to total losses has been observed in the appraisal wells.

Water Influx /H_2S: Sulphurous Water Influx has occurred from Ilam and Jahrum formations.

Stuck Pipe: In the Jarhum and Sachun equivalent stuck pipe often occurs due to total losses, pack off and poor hole cleaning (tight hole). It is important to keep a high flow rate and pump hi-vis pills frequently. Use of roller reamer will also help to avoid stuck pipe.

Harsh Drilling Environment: In the Jahrum formation, mechanical sticking and irregular rotary torque cause serious damage and fatigue to equipment from shifting of Limestone slabs in the formation. Several twist offs and sidetrack has occurred in the Jahrum formation. Jahrum and Sachun are both very abrasive formations. This is causing rapid stabilizer deterioration, bit gauge wear. Bit bounce (high axial vibration load) is a predominant feature using a rotary BHA. Insert bit will be used to cope with the hard formation. Use of checklist and inspection programs of drill string has to be used to avoid twist offs.

2.2 Drilling Procedure

The plan for the section is to drill section with 2 BHA run if required bit trip. BHA#1 is including 22'' IB string stabilizer, jar and accelerator to drill out 26'' CP shoe into Jahrum formation/Loss zone. BHA#2 is including shock absorber, 22'' IB string stabilizer, jar and accelerator to drill bottom part of this section to TD. Section TD (+5 -10m rat hole) will be to set casing shoe +/-20 mTVD into the Ilam Fm. It is highly recommended to use under-gauge stabilizer.

2.3 Drilling Fluid

At start of operations the 30" x 26'' conductor will be filled with seawater. Drilling of this section, clean out of the 26" shoe and clean up of the rat hole will be done with seawater and hi-vis pills. Hole cleaning is a major focus point for this section. Have minimum 300 bbl 10 ppg kill mud ready to be pumped at all times during drilling operation. This will be used as displacement mud at TD. For detailed mud treatment procedures it is refer to MI Services Mud Program (this program includes contingency material/ minimum stock requirements, loss mechanisms and contingencies, hole cleaning issues, drilling of cement, bit balling, sag, fluid displacement , H_2S treatment, treatment of fluid to be left behind casing etc.). All pills will be formulated with H_2S scavenger to neutralize H_2S and minimize corrosion. For protection of the drill string, a filming agent (Conqor 202B) will be used. This will be used in slugs and sprayed on DP when tripping in/out of hole.

2.4 Proposed Drilling Mud and Hole Cleaning Practice

If high torque during drilling or connection, sweep hi-vis pills and circulate. Ream each single the first stand into Sachun equivalent during drilling and tripping. Spot hivis pill on all connection. Pump/Spot pills and start up after connection with 800 gpm when pills enter bit. Sweep and spot hi-vis pills if washing/reaming in Jahrum Fm on wiper trip. Ensure viscosity of pills is below 120 sec. Circulate and work pipe every single and back ream each stand gently. Always keep back free. If there ever is a need to keep the string stationary over a period of time the flow must be reduced to avoid washouts. Never ream on way down. Slide fast down and ream up if necessary. Focus on avoiding accidental sidetracking. Prior to BHA trips, sweep hole with

60 bbl GG and 60 bbl PHG. At TD, sweep hole with 120 bbl PHG pill and circulate hole clean. Spot 800 bbls 10 ppg Hi-vis PHG mud from bottom to top of Jahrum or loss zone prior to POOH if changing BHA and when at TD. Treat all mud and pills with H_2S scavenger. Sea water left behind casing to be treated with H_2S scavenger. Be careful when drilling in the transition zone between Jahrum Fm and Sachun equivalent Mbr. Drill 10m, then ream back, repeat for the first stand. Caliper logs showing up to 46'' hole in the Jahrum Fm has been experienced.

2.5 Lost Circulation Strategy

There are Partial losses in Asmari, Partial to total losses in Jahrum and Sachun equivalent. Losses occur due to natural fractures and karst (voids and channels), and is not due to equivalent circulation density (ECD). Losses occur due to natural fractures and karst (voids and channels) surfaces, and is not due to ECD. The strategy for treating losses is that the cuttings will heal the loss zone. Drill with floating mud cap; topping up annulus with seawater to prevent under-balance in well and H_2S migration. Use fill-up line to the bell nipple for filling into annulus. It is important to keep high pump rate if losses occur to clean hole and avoid stuck pipe.

2.6 Stuck Pipe Strategy

It is important to keep a high flow rate and pump hi-vis pills frequently. Stuck pipe situations occurs due to poor hole cleaning (due to losses) and larger pieces of formation jamming the BHA(Mechanical sticking).

2.6.1 Mechanical Sticking in Jahrum

1. Drill with as low RPM as possible
2. Set back one single at connection to enable jarring down if stuck after connection.
3. Wash each stand gently with low/no rotation and flow.
4. Set torque limit low to be able to detect a pack-off early if rotation needed.
5. Set a Hi-Visc Pill around BHA on Connection
6. Be aware of the transition zone between Jahrum and Sachun equivalent formation.
7. Wipe each single back into Jahrum on the first stand inside Sachun equivalent during drilling and tripping.
8. Set a Hi-Visc pill at connection during drilling and during tripping.

Lubricate OOH with low/no flow (only keep the hole filled). If mechanical stuck be patient, first try to use rotation of DP to crush the formation pieces, start jarring at a low force to prevent getting jammed up. Do not start jarring with max force. When reaming, move pipe down and reduce pump rate immediately if over pull/ pack-off occur to avoid fracturing formation. Never apply full overfull before allowing the jar to hit. Never jar up with torque in string. Always hit jar in opposite direction getting stuck (most likely the jar should be hit downwards). Driller shall be aware of max pull on jar and drill string. Use jar in combination with accelerator in BHA. Never run Jar/Accelerator in neutral point. Use under-gauge stabilizers in the BHAs**.** If hole packs off, do not jar or apply over-pull:

1. Stop the pumps immediately.
2. 'Break' the string free by applying torque to the string and at the same time move the block up and down close to neutral weight –do not attempt to circulate.
3. Rotate and move pipe up/down -wards (rack back a stand if required) until pipe can be moved freely. Wipe a section of the hole and attempt to regain circulation.

3. Objectives for 16" Hole Section

The objective of the 13 3/8" intermediate casing is to isolate the oil bearing Dariyan Formation and the potentially weak Fahliyan formation. The shoe will be set 20 mTVD into the Hith anhydrite at +1715 m RT.

3.1 Potential Drilling Challenges

Tight Hole: Tight hole due to reactive shale or hole instability in Kazhdumi and Fahliyan Fm. Calliper logs in appraisal wells showed 22" hole in Kazhdumi (17 ½" bit). Tight hole also observed in Sarvak, Dariyan, Gadvan and Fahliyan.

Bit Balling and Gumbo: Bit balling and gumbo can occur in the Kazhdumi shale.

String Twist off and Wash-outs: Drill string twist off and wash-outs will occur due to potential H_2S and vibrations.

Sulphurous Water Flow: In the Kazhdumi Fm. Water Influx can occur if not suitable hydrostatic head is maintained and in the Gadvan fm., Oil Influx can occur if not suitable hydrostatic head is maintained. Decrease in hydrostatic head can occur due to losses in the Fahliyan fm. It is important to keep a floating mud cap with H_2S scavenger. Treating of mud and spray film on DP to avoid twist off due to H_2S.

Losses in Fahliyan: Possibly losses has been caused by local porous zones and/or faults/fractures.

1. Possible caused by localized dolomitisation.
2. Treat losses with LCM
3. Drill with floating mud cap; topping up annulus with seawater or mud
4. Losses in the Fahliyan Fm during cementation.

Stuck Casing: Over-pull of 180 t was experienced in SP-10 (phase 7) in the Fahliyan / Hith Fm.

3.2 Drilling Procedure

The plan for the section is to drill section with 2 BHA run if required bit trip. Section TD will be 25 mTVD into the Hith anhydrite. The BHA will include string stabilizers and jar/ accelerator. Reduce Drilling parameters/ ROP in the Fahliyan Cherty zone. Avoid damaging the bit in Cherty zone. At connection, ream up only 1 single with maximum flow rate and 40-60 RPM, and ream down with reduced flow rate and 40-60 RPM. If back reaming needed in the Kazhdumi and Laffan Fm., back ream with Minimum 5min/stand with maximum flow rate and 40-60 RPM.

3.3 Drilling Fluid

At start of operations the 18 5/8" casing will be filled with seawater. The drill out of the 18 5/8" shoe track / clean up of the rat hole and the drilling of 3 m new formation will be done while displacing to the well to 9.58 ppg KCl/Glycol/ Polymer mud. Drill Kazhdumi Fm. With 9.58 ppg mud. Keep mud weight between 9.41ppg – 9.58 ppg below Kazhdumi Fm. Higher mud weight might cause losses in the Fahliyan Fm. At TD evaluate the hole conditions and optimize mud for casing running. Fill every joint with 9.41 ppg mud during casing running. Treating of mud and spray film on DP to avoid twist off due to H_2S. Up to 3 % Glycol could be used in the mud if required.

3.4 Proposed Drilling Mud and Hole Cleaning Practice

Back ream each stand gently. If there ever is a need to keep the string stationary over a period of time the flow must be reduced to avoid washouts. Avoid reaming on way down. Slide fast down and ream up if necessary. When rotating down reduce flow rate. Perform wiper trip if required especially through the Kazhdumi Fm. Treat all mud with H_2S scavenger. Mud and spacer left behind casing to be treated with H_2S scavenger. Keep focus on mud parameters (bit balling and gumbo in the Kazhdumi shale). For hole cleaning, ensure annulus is circulated clean above BHA prior to stop pumping for connections. Min 2 times BHA/annulus volume. To prevent bad hole cleaning and high ECD, the following parameters should be focused:

1. Hole cleaning / cutting trend plot
2. Torque / Drag / Pump Pressure trend plot

3.5 Lost Circulation Strategy

In the Fahliyan Fm. Partial to total losses was experiences in some of wells on SPD1 and SPD2 and SPD7. The Fahliyan Fm may be picked by a drilling break. The loss mechanism is believed to be localized dolomitisation. However, high ECD should not be excluded as a cause of losses. When breaking circulation, increase pump strokes in steps and move pipe slowly up to prevent breaking down the formation. If over pull / pack-off occur when reaming upwards, move pipe down and reduce pump rate immediately to avoid fracturing formation. If losses are experienced, consider to dust in fibers to active system. Also consider to spot LCM pill across the lose zone. The rig shall have sufficient LCM materials onboard and LCM pills ready mixed up prior to drilling into the Fahliyan Fm. Try to cure losses with LCM pills, if unsuccessful, the strategy for treating losses is that the cuttings finally will heal the loss zone. Drill with

floating mud cap (trip tank); topping up annulus with H_2S treated mud to prevent under-balance in well and H_2S migration. It is not Planned to use cement to cure lost circulation due to severe contamination of the mud system.

3.6 Stuck Pipe Strategy

Be aware of possible stuck pipe due to falling cement blocks while drill out 18 5/8'' shoe and cleanout rathole. Tight hole due to reactive and swelling shale in Laffan, Kazhdumi and Gadvan Fm. Tight hole in Fahliyan Fm. Stuck pipe mechanism occurs due to tight hole (Mechanical sticking). Use drilling pup to enable jaring or moving pipe down if stuck after connection. When reaming in tight Kazhdumi and Fahliyan Fm, reduce reaming speed to avoid getting stuck or pack off. Always hit jar in opposite direction getting stuck (most likely the jar should be hit downwards). If mechanical stuck be patient and start jarring at a low value to prevent getting jammed up. Don't start jarring with max force. Never apply full OP before allowing the jar to hit. After the jar has hit, max DP overpull to be applied. Never jar up with torque in string. Driller shall be aware of max pull on jar and drill string. Use jar in combination with accelerator in all BHAs.

4. Objectives for 12 ¼" Hole Section

The objective of this section is to seal of the Aghar Shale and the 9 5/8" x 10 ¾" casing shoe will be set 20m into the Upper Kangan formation at +2890m RT to be able to complete the well by installing a 7" liner.

4.1 Potential Drilling Challenges

Low ROP: Low ROP has been experienced in the Surmeh and in the Hith Formation.

Lost Circulation: Complete losses were occurred in Upper Dolomite member at SPD9-09, 11, 14, 15 in Phase 8. Losses in caused by local porous zones and fractures. Losses were observed in SPD12B-08 appraisal well at depth of 1775m (in Upper Dolomite) with 80 bph dynamic loss, static flow check showed 55 bph loss. Decreased flow rate to 850gpm. Losses gradually decreased to zero at 1809m. Total down hole loss: 184bbls. Upper Surmeh: If MW exceeds 9.6 PPG. Probably caused by localized fracturing / faults and/or porous formation. Surmeh and Neyriz are potential loss zones. Pack-off in Aghar shale with subsequent losses. Losses while running and cementing 9 5/8" x 10 ¾" casing.

Differential Sticking: Differential sticking were observed across loss zone (experienced in SP-11) and Upper Surmeh Limestone.

Mechanical Stuck in Sudair (S8) and Aghar Shale: Stuck pipe often occurs on a connection due to poor hole cleaning and sudden pack off / hole collapse. Heavy back reaming could be required in this section. It is important to keep back free. In two wells calliper logs were run, showing over-gauge hole (S8: 12"-15", Aghar: 15"-20"). The mechanism may not be reactive shale since both these shales are Trias age. The reports of caving, suggests either a geo-pressured shale or unstable fractured shale. Stuck while running casing.

Over Pressurized Zones: SPD7-02 in Phase 6, SP-15, SPD10-08 wells In Phase 9 experienced salt water kick, at low influx rate in Dashtak"B" calculated to, increased mud weight to 17.33 ppg (2.08 SG).

SP-7,3H1 and SP12, experienced salt water kick at low influx rate in Sudair Formation, calculated to 15.62 ppg (1.82sg) and in SP-12 salt water flow was observed at top of Sudair, increased mud weight to 16.94 ppg (2.034sg).

4.2 Drilling Procedure

The plan is to drill the section with 3 bit run. Section TD will be to set casing shoe 20 mTVD into the upper Kangan Fm. Rathole to be drilled minimum 5m below casing depth. The BHA will include string stabilizer, jar/accelerator.

4.3 Torque and Drag

Torque and drag must be monitored and trend plotted on connections and against theoretical simulations as an important indicator of hole cleaning.

4.4 Drilling Fluid

A KCL, Glycol, Polymer mud is planned to use in this section. Initial MW is planned for 9.41 ppg. Do not increase mud weight before drilled through possible loss zone in Surmeh, Upper Surmeh Member. Keep pH above 9.5**.** Drill with 9.41 ppg MW to max bottom of Evaporate B to avoid differential sticking while tripping. Increase MW according to mud weight plot. Increase MW to 11.75 ppg prior to drilling into the Sudair shale (S8)**.** Final MW planned to 11.75 ppg**.** Allow KCL and Glycol to deplete in upper part of Surmeh. However, keep minimum 1.5% Glycol and 30 kg/m3 KCl in the mud (SP68 Best practice)**.** Evaluate to keep 3% Glycol and 70kg/m3 KCL in whole section to reduce back reaming time. Minor trip gas (0.27%) was observed at bottom of Evaporate B in SP-9**.** Trip and connection gas were experienced in SP-9 (Phase 8) from Upper shales**.** The water kick experienced in well SPD7-02 would have required a MW above 16.5 ppg EMW to kill the kick. It is recommended to drill the section and run casing with a lower MW without killing the kick due to low inflow rate, if a similar situation occur. Based on the pressure seen in well SPD7-02 there was a leaking zone higher in the section, possibly in the Upper Surmeh. Optimize properties of mud left inside casing to minimize settling**.** Optimize solid control (screen size and centrifuges)**.** Treating of mud and spray film on DP to avoid twist off due to H_2S.

4.5 Proposed Drilling Mud and Hole Cleaning Practice

Circulate and back ream each stand gently. If there ever is a need to keep the string stationary over a period of time the flow must be reduced to avoid washouts. Avoid reaming on way down. Slide fast down and ream up if necessary. When rotating down reduce flow rate. Clean hole prior to entering Upper and Lower Sudair shale and Aghar shale. Low RPM and circulation when reaming through Upper and Lower Sudair shale and Aghar shale. Perform wiper trip if required. If pumping/reaming OOH, circulate clean (min 1.5 x BU). To prevent bad hole cleaning and high ECD, the following parameters should be focused:

1. Hole cleaning, cutting trend plot
2. Torque, Drag, Pump Pressure trend plot

Treat all mud with H_2S scavenger. Mud and spacer left behind casing to be treated with H_2S scavenger, Biocide, Oxygen scavenger, Corrosion inhibitor.

4.6 Lost Circulation Strategy

Based on experiences, lost circulation will be a major issue in the Upper Surmeh, Upper Dolomite, Surmeh formations and there have been huge problems to cure these losses in previous wells. When breaking circulation, increase pump strokes in steps and move pipe slowly up to prevent breaking down the formation. If over pull / pack-off occur when reaming upwards, move pipe down and reduce pump rate immediately to avoid fracturing formation. Try to cure losses (seepage/severe) with LCM (fine/cross linking) treated into the mud together with cuttings. The strategy for treating losses is to continue drilling. The cuttings in combination with LCM will heal the loss zones (based on experience from SP-11). Total losses were occurred in Upper Dolomite Mbr. in SPD9-09, 11, 14, 15 deviated wells in Phase 8. It was experienced that to reach to TD at 20 TVD m in Upper Kangan formation with increasing MW in lower part of the section from 9.58 ppg to 11.75 ppg SG, it is necessary to cure the loss zone with LCM and Cement. Then squeeze Cement to the loss zone to achieve equal to 11.33 ppg FIT. This type of curing and cementing job prevent breaking the cured loss zone and loss circulation when drilling in the lower part of the section with increased MW. Try to spot fine LCM pill through MWD tool. The rig shall have sufficient LCM materials onboard and LCM pills ready mixed up prior to drilling into the Upper Surmeh Fm.

4.7 Stuck Pipe Strategy

In the Neyriz/Sudair (S8)/Aghar shale, stuck pipe often occurs on a connection due to poor hole cleaning and sudden pack off /hole collapse. Heavy back reaming could be required in this section. Keep back free and reduce reaming speed to avoid getting stuck or pack-off. When reaming, move pipe down and reduce pump rate immediately if over pull/ pack-off occur to avoid fracturing formation. Never apply full OP before allowing the jar to hit. After the jar has hit, max DP OP to be applied. Never jar up with torque in string. Always hit jar in

opposite direction getting stuck (most likely the jar should be hit downwards). Driller shall be aware of max pull on jar and drill string. Use jar in combination with accelerator in all BHAs.

4.8 Hole Stability

In the carbonates in and above the reservoir the mud density should be designed only for well control and lost circulation purposes. Boreholes are predicted to remain stable in the carbonates (without cavings) at all mud densities between the pore pressure and the fracturing pressure. Borehole collapse will occur in the Sudair and Aghar Shales.

5. Objectives for 8 ½" Hole Section

In this section, the 8½" hole will be drilled to TD at 20m in Nar member at +3320m RT. This section will be completed using a 7'' liner to case off the Kangan and Dalan formations. Total depth will be confirmed by well-site geologist and reservoir geologist.

5.1 Potential Drilling Challenges

H_2S: The Kangan/Dalan is a known over pressured sour gas bearing (up to 5000 ppm H_2S) reservoir. All necessary precautions relating to H_2S operations will need to be taken while drilling the reservoir section.

Differential Sticking: The significant height of the gas column in the Kangan/Dalan combined with the potential higher than normal mud weight and depletion of the K4 due to production on other phases and the North Field (Qatar) could result in a significant overbalance at base of the reservoir. The potential for differential sticking in this section is high.

Losses: Offset data indicates that the risk of significant losses in this hole section are low, except for SPD2-05 where significant losses were observed in the K1 and SPD4-01. There is risk of partial to complete losses in Lower Dalan formation.

Drilling Fluid: A KCL/ Glycol Polymer mud system from 12 ¼'' section will be used to drill this section. Initial MW is planned for 11.5 ppg it could be increased gradually if required. Prior to drilling out shoe, ensure correct mud weight to avoid a well control situation. $CaCO_3$ will be considered for avoiding differential sticking. Centrifuges should be avoided, as these may remove the $CaCO_3$ from the mud system. Have Pipe-Lax available.

5.2 Proposed Drilling Mud and Hole Cleaning Practice

To prevent bad hole cleaning and high ECD

1. Hole cleaning / cutting trend plot
2. Torque/Drag/Pump Pressure trend plot

Back ream each stand gently. If there ever is a need to keep the string stationary over a period of time the flow must be reduced to avoid washouts. Perform wiper trip if required. Be aware of swabbing. Pump out of open hole. Circulate hole clean (min 1.5 x B/U) with max rate 1 std inside shoe. Keep fluid loss below 3 ml/30min. It is recommended to keep fluid loss below 2 ml/30 min. Treat all mud with H_2S scavenger.

5.3 Lost Circulation Strategy

Only seepage losses have been reported for the SPD1 and SPD2 wells, except for SPD2-05 where significant losses were observed in the K1 and SPD4-01. When breaking circulation, increase pump strokes in steps and move pipe slowly up to prevent breaking down the formation. If over pull / pack-off occur when reaming upwards, move pipe down and reduce pump rate immediately to avoid fracturing formation. PBL sub (multiple circulation sub) is not planned used in the string, hence use only fine LCM. Avoid using cement as LCM to cure losses due to severe contamination of the mud and increase in skin.

5.4 Stuck Pipe Strategy

Differential sticking:

1. The K4 reservoir could be depleted due to production on other phases and in the North Field (Qatar).
2. Keep the fluid loss below 2 ml to avoid sticking filter cake
3. Minimize connection time
4. Always rotate/reciprocate/pump if stop in operations

If differential sticking occurs, it will be considered to pull out with the PDM/MWD BHA and drill the remaining with a rotary BHA (without MWD/PDM). Have acid (HCl) on the rig in case a differential sticking situation occurs. When reaming, move pipe down and reduce pump rate immediately if over pull/ pack-off occur to avoid fracturing formation. If differential stuck start jarring at max hit on the jar to prevent getting even more differential stuck. Never apply full over pull before allowing the jar to hit. After the jar has hit, max DP over pull should be applied. Never jar up with torque in string. Always hit jar in opposite direction getting stuck (most likely the jar should be hit downwards). Driller shall be aware of max pull on jar and drill string Use jar in combination with accelerator in all BHAs.

6. Results and Discussion

In this paper the best operational strategy to avoid pipe sticking and to reduce the effect of this event has been presented. At the most time, mentioned strategies are useful and efficient to prevent pipe sticking in such formations and various drilling operations results prove it. Drilling operations show that it is important to keep a high flow rate and pump hivis pills frequently. Lots of stuck pipe situations occurs due to poor hole cleaning (due to losses) and larger pieces of formation jamming the BHA that leads to mechanical sticking.

References

[1] Degeare, J., Haughton, D., McGurk, M.:"The Guide to Oil Well Fishing Operations",2003.
[2] Kingsborough, R. H., Hempkin. W. B.:"Multivariate Statistical Analysis of Stuck Drill Pipe Situation", SPE 14181, 1985.
[3] Moore, P. L.:"Drilling Practice Manual", Petroleum Publishing Co. Tulsa,1976.
[4] Lens Chow, J.R.:"Pressure Drop Calculation for Drilling Fluids",SPE 25520,1992.
[5] Demirdal, B., Cunha, J.C.:"Pressure Losses of Non Newtonian Fluids in Drilling Operation", SPE 108711, 2007.
[6] Biegler, M.W., Kuha, G. R.:"Advances in Prediction of Stuck Pipe using Multivariate Statistical Analysis", SPE 27529, 1994.
[7] Howard,J.A., Glover, S.B.:"Tracking Stuck Pipe Probability while Drilling", SPE 27528, 1994.
[8] Schotlet, T.:"Guidelines for the Prevention and Cure of Stuck Pipe", BP Research, 1989.
[9] Watson, B., Smith, R.:"Training Reduces Stuck Pipe Cost and Incidents", Oil and Gas Journal, 1994.
[10] Motiee, H.: "Zagros Stratigraphy", Iranian Geological Survey, Fifth edition, Tehran, 1995.
[11] Meschi, M. R., Shahbazi, K., Pordel, M.: "A New criteria to Predict Stuck Pipe Occurrence", SPE 128376, 2010.