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Stuck Pipe Prediction And Avoidance: Invocation Of Basic Principle Of Standard Methods, Pre And Post Sticking

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ABSTRACT

Stuck pipe in geothermal well drilling occurs when the drill string in the wellbore cannot be pulled out without exceeding its designed working load. These incidents lead to non-productive time and unnecessary additional drilling costs. Statistics across the drilling projects indicate that stuck pipe is by far the greatest cause of lost time during drilling operations. Despite the progressive experience accumulated over the years in drilling operations, the stuck pipe occurrence is increasingly becoming a common phenomenon in accelerated drilling operations in Olkaria geothermal field. To free the stuck pipe is time consuming, costly, sometimes having to re-drill the well, or at the very worst losing the wellbore itself. In well planning, the key to achieving objectives successfully is to design drilling programs on the basis of anticipated potential hole problems. Understanding and anticipating stuck pipe problems, their causes, and planning solutions is necessary for overall-well-cost control and for successfully reaching the target zone. To exercise a holistic approach into this problem, stuck pipe avoidance team (comprising of well designers and implementers) need to be set up to develop and own strategies that can mitigate stuck pipe incidents. For continued improvement, it is highly important for the inter-disciplinary drilling operation crew to collectively, closely and proactively monitor step-wise drilling process with strict attention to detail. The team will be able to estimate the risk of occurrence of stuck pipe not only during drilling but also at well planning stage. Though it is good enough to solve a problem, it is always better to avoid it in the first place. This is the basic principle upon which this paper seeks to establish.

1. INTRODUCTION

Geothermal drilling world over has never been known to be trouble free. To study the frequency and severity of specific troubles, it was valuable to sample drilling history from a large cluster of drilled wells in Olkaria. In essence, drilling problems can be very costly. Within Olkaria geothermal field where this case study has been conducted, the most prevalent drilling problems encountered includes and not limited to; pipe sticking, lost circulation, pipe failures, borehole instability, formation damage, hole cleaning and equipment break downs. Based on a statistical data on major drilling problems encountered spanning from 2014 to 2019, 54 cases have been identified and investigated. Of the stated problems, stuck pipe incidents have been observed to be the most prevalent and costly occurrence in drilling operation accounting for 79.6 %, a situation that led to loss of huge sums of money. This lost money could have been allocated to other deserving areas or cumulatively added up to drill more wells. The challenges experienced in the course of drilling can act as a spring board to advance expertize in this industry if well utilized. One way to gain out of the stuck situation is to try to identify the cause of the problem, analyze it, solve it and keep the data for future reference if similar problems recur. This data can be vital to problem avoidance when planning future drilling programs if a certain level of subjectivity is applied. But most importantly, training and crew awareness are the key factors in stuck pipe prevention.

This investigative work therefore attempts to logically demonstrate what the cause of the stuck pipe situations could have been, and realistically suggest the possible solutions/preventive measures to avoid (where possible) or minimize the frequency of occurrence. While aware that these problems will certainly occur in future, even in very carefully executed process control, most cases of stuck pipe, well over 90%, are avoidable with good planning, focused attention, task perseverance and listening to the hole [1]. To a great extent, the cause of stuck pipe is related to human inability to grasp all the information pointing at the approaching problem. This can partly be explained by the fact that there is less emphasis placed on stuck pipe prevention. As is often known, problems don't just happen, but they are as a result of chain of critical events leading to the end incident. Since these incidents are persistent, development of a logical countermeasure is paramount. This therefore, has been the prime motivation resulting into the preparation of this paper.

In the investigation to the stuck pipe incidents, a closer look was therefore paid to the events preceding the stuck situation and the undertakings thereafter until the drilling assembly was free or otherwise. The stuck time was calculated from the instance of stuck situation and drilled depth to the last one hour before the next bottom drilling was commenced, or the start of a plug job before formation drilling, trip out of hole to terminate the well or the moment when that decision was made. Therefore, for better understanding, clear and precise evaluation of the stuck incidents, various aspects of drilling process were highlighted and investigated to find out their contribution to stuck pipe situation. These included; the type of formation under bottom drilling, drilling control parameters, drilled depth, the type of drilling mud in application, the status of circulation returns, the geometry of the hole section, the orientation design of the well, the inclination angle and azimuth at the point of stuck, the BHA design and the actual activity in progress or shortly before getting stuck.

2.0 GENERAL FINDINGS

2.1.0 Depths at Which Stuck Pipe Occurred

In this investigation, the stuck incidents were plotted against the stuck depth as shown in figure 1. It was therefore found that 86.96% of all the stuck pipe cases happened in shallower depths above 1000m. These findings therefore make this region a point of interest that calls for more than average attention by the relevant stakeholders. As earlier mentioned, in well planning, the key to achieving objectives successfully is to design drilling programs on the basis of anticipated potential hole problems. At the design stage of a well, planning and preparing for drilling challenges in the range of 60m to 1000m is key. Below 1500m, the stuck pipe cases have not been common.

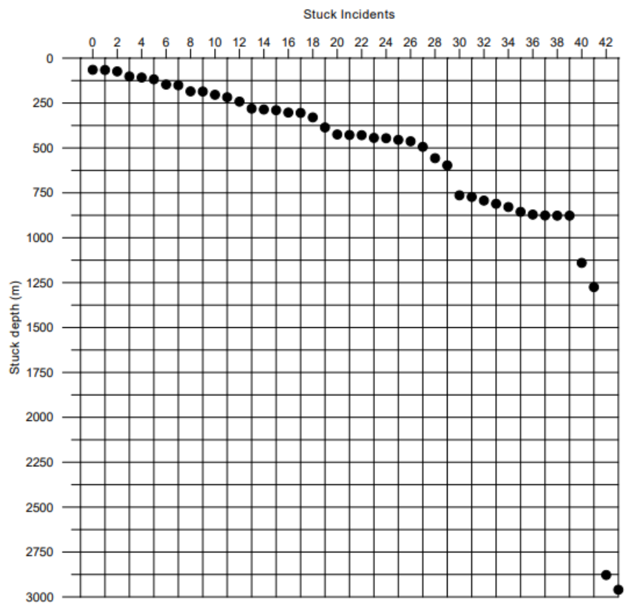


Figure 1: Stuck depths with time progression

2.1.1 Drilling Fluid

Most stuck pipe occurrences happened while using aerated air and foam at 65%, water at 26.92% and mud at 3.85% as is indicated in figure 2. As has been observed, drilling fluids can create as many problems as they can solve. Application of the correct mud system is therefore crucial if drilling troubles were to be avoided.

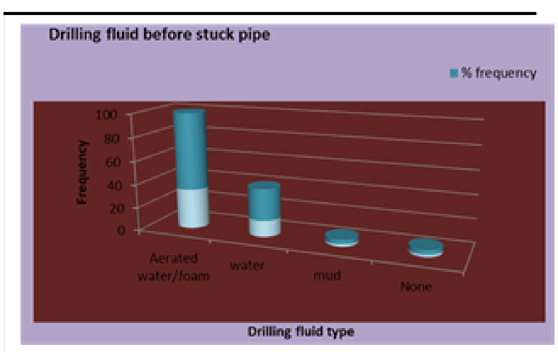


Fig. 2 drilling fluid on use at the instance of stuck pipe.

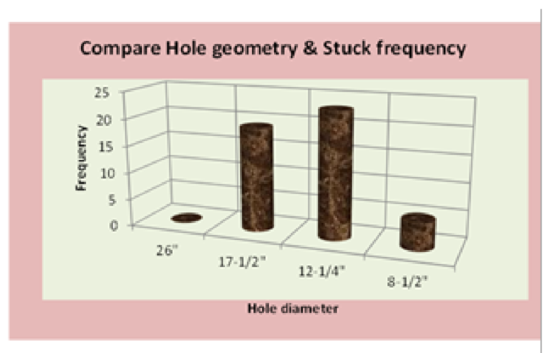


Fig. 3 Hole geometry relative to stuck pipe

2.1.2 Geometry of Hole

With other factors held constant, the diameter of the hole section was considered with respect to stuck pipe incidents in trying to relate the sensibility of the hole section to stuck pipe occurrence. Under gauge hole arising from drilling long sections of abrasive formations was noted to have been as a direct result of stuck pipe. As shown in figure 3, most stuck pipe incidents happened while drilling the main hole section (12-$^{1}/_{4}$'') at 49% and interestingly 11% of stuck cases during production hole, which is the longest hole section. No stuck pipe instance was reported while drilling surface hole.

2.1.3 Status of Circulation Returns

When intermediate or severe losses occur, cuttings will settle out around the BHA, and mechanically stick the pipe. The cuttings will act as a packer, and make the losses worse. It was observed that 64% of stuck pipe incidents occurred while circulation returns was received on the surface, 29% during blind drilling (total loss of circulation) and 7% with partial returns. More often, it is assumed that with full circulation returns, chances for getting stuck are minimal contrary to the findings of this research. According to C. Bowes & Procter [Drillers Stuck pipe Handbook, 1997], the effect of mud rheology on hole cleaning depends on the annular flow regime. When laminar flow exists, increasing the mud viscosity will improve hole cleaning. This is particularly effective if the low shear rheology and YP/PV ratio are high.) · When turbulent flow exists, reducing the mud viscosity will help remove cuttings [2], [3].

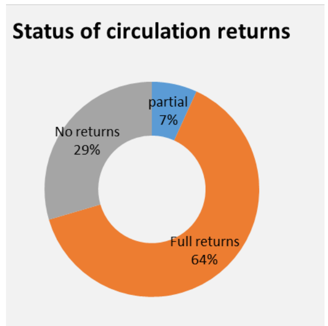
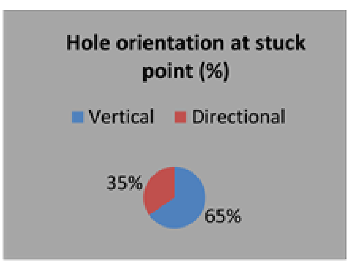
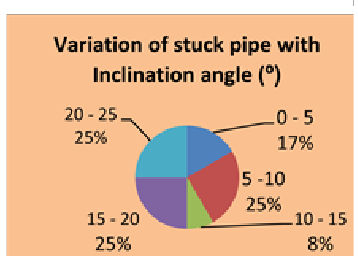


Fig. 4 Stuck pipe in relation to status of circulation

2.1.4 Hole Orientation

As figure 5 indicates, 65% of problems were encountered while drilling the vertical section of hole contrary to anticipated deviated section which conventionally poses more challenges due to cleaning problems. The hole pack-off incidents which have immensely contributed to stuck pipe happened majorly in vertical sections of the hole. Arising from these findings, potentially risky hole sections should be drilled with rotational drill string, even if it requires to re-programme motor kickoffs [3].





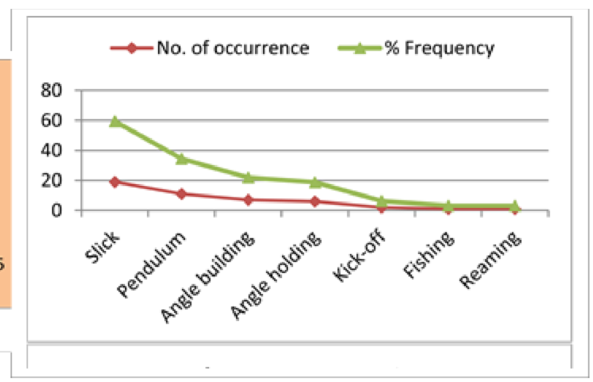


Fig. 5 Effects of hole orientation **Fig. 6 Effects of inclination angle** **Fig. 7 Effect of BHA with respect to stuck pipe**

2.1.5 Inclination Angle

It was noted that stuck string was experienced due to doglegs/ledges that was developed especially during kick-off and angle building section of the hole. It was during trip out that most stuck situation was experienced as figure 6 indicates. Below 5º of deviation from vertical trajectory, less stuck problems was experienced at 17% and 25% during angle build up to 20º.

2.1.6 Bottom Hole Assembly (BHA) Configuration

Each BHA configuration was found to play a key role in relation to stuck pipe. Though slick BHA has no stabilizers mounted, it contributed as much as it is easy to think of it less risky, contrary to the findings established in this investigation. Slick BHA significantly contributed to 40.4% while pendulum configuration at 23.4%. Reaming BHA had least stuck pipe occurrence at 2.1% as is shown in figure 7. It is therefore recommendable that, in the change of BHA from one configuration to another, care must be taken while tripping in to prevent it from sticking. This is what happens if the previous drilled hole is under gauge. At no point while tripping in hole should the BHA weight be slacked off at a tight spot. While reaming, it should be done gingerly so that the BHA is not screwed into the formation [4].

2.1.7 Activity Before Stuck Pipe

For better understanding of the true cause and stuck mechanism, it was of interest to review the drilling activity on progress shortly before, during and after stuck pipe situation. Figure 8 shows 60% of cases to have occurred while drilling on bottom, 10% while making up the pipe and in the least of cases while reaming and waiting on repairs at 1.67% each respectively.

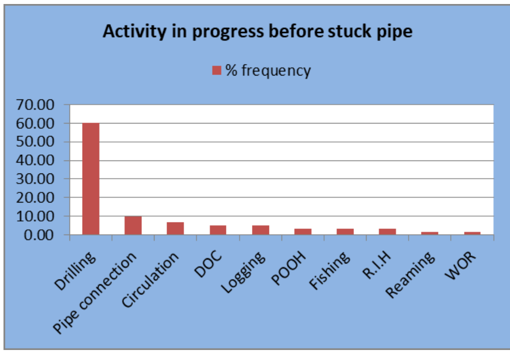


Fig. 8 Activity prior to stuck pipe

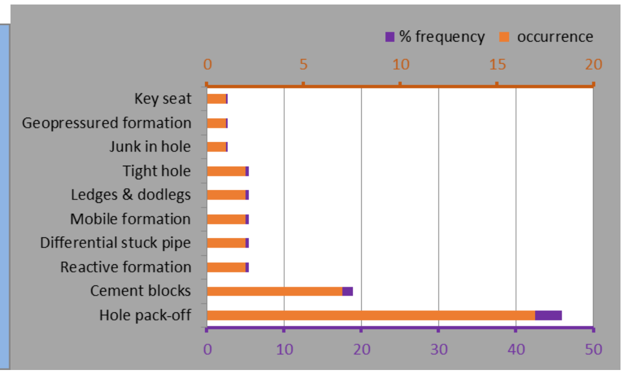


Fig. 9 Stuck mechanism

2.1.8 Mechanisms of Stuck Pipe

Most cases of stuck pipe are avoidable with proper attention to detail, and once stuck pipe is recognized, fast action is necessary. The best chance of getting free is just after getting stuck. Recognizing the different ways drill pipe can get stuck is the first step in prevention and recovery [4]. Before any attempt is made to get the drill string free, it is of paramount importance to try and identify the possible cause and mechanism of stuck pipe. Different stuck mechanisms may require different approach if any success to overcome the problem is to be achieved in timely and cost effective manner. For instance, due to insufficient hole cleaning, when the circulation stops, cuttings will settle around the drill string, effectively leading to hole pack-off, which in this case accounted for 45.95% of stuck pipe. Cement blocks related stuck situations was established to have been 18.92% while key seats, geopressured formations and tight hole was found to contribute the least stuck pipe incidents at 2.70% respectively as indicated in figure 9. Pipe stuck in a key seat which was one of the least contributors to stuck pipe had occurred at 2.7% of the total cases.

2.2 Non Productive Time (NPT)

If trouble were not a major factor in drilling time, wells drilled to similar depths in any one given site would require similar amounts of time to drill. The uncertainties associated with geothermal drilling and the variability of drilling rates would cause dispersion around the average or expected drilling time [5]. However, due to stuck pipe as a major consumer of time in drilling, this research work found great dispersion that dominates the drilling time-depth relationship.

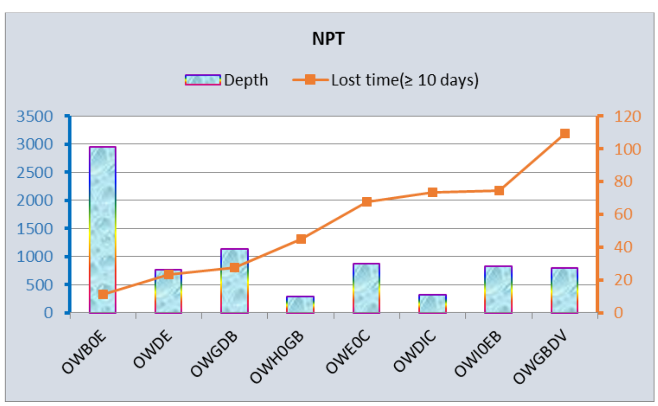


Fig. 10 NPT relative to stuck depth

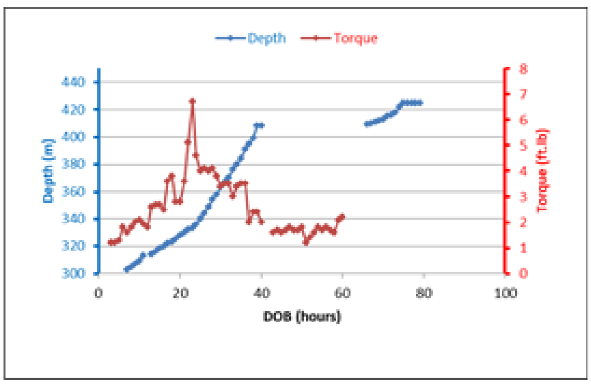
The NPT arising from stuck pipe was found to range from as low as 1 hour to as high as 2616 hours. Some of the worst times of stuck situation in terms of NPT are as indicated in figure 10. At a depth of 793m, geothermal well referenced as OWGBDV incurred a total loss of 109 days, making it the worst case of stuck pipe situation.

3. CASE STUDIES

In the 54 cases that were identified, 38 of them were as a direct result of mechanical and differential pipe sticking. In this investigation, just a few cases has been highlighted and discussed in this paper. In the findings, hole pack-off was the most prevalent cause of stuck pipe comprising 45% of the cases. Cement blocks was identified to cause 18.92% of stuck pipe. Overall, mechanical pipe sticking comprised 94.59% while differential sticking accounted for 5.41% of the cases. A few of those identified cases of stuck pipe incidents has been subsequently discussed.

3.1 OWGBDB Cause – Hole Pack off

The hole had been drilled to 303m and cased at 300.27m. The cement was tagged at 277m (26m above the drilled depth). The drilling on bottom (DOB) was continued to 408m after which the BHA was changed to reaming. The reaming process transcended to last phase of circulation before pulling out of hole (POOH) to change BHA to kick-off. There was no circulation returns for first 16 hours of reaming with water. After introduction of aerated water & foam, there was observed partial returns. After resumption of bottom drilling, the circulation returns was positive for the first 7 hours before the situation changed to partial returns. The deviation survey was conducted at drilled depth of 425m and lasting for one hour. Soon after the end of deviation survey, it was then realized that the string was already stuck. After several unsuccessful attempts to free the drill string, a back-off was conducted after which running in hole (R.I.H) of $3^1/_2$" wash pipe was commenced. The fish was successfully tripped out of hole afterwards.



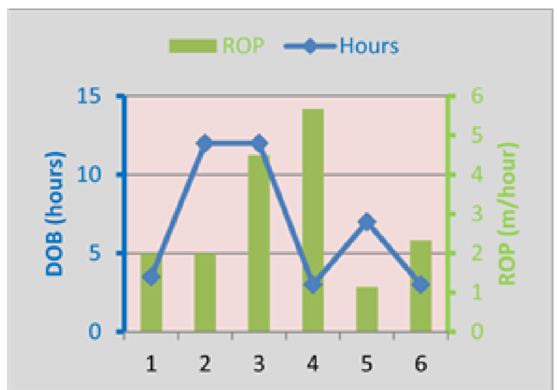
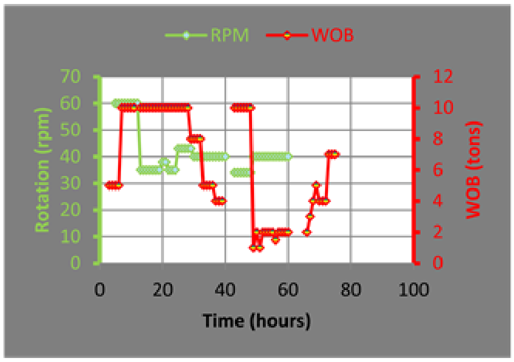


Fig. 11 Drilled depth vs. corresponding torque **Fig. 12 ROP trend before stuck pipe**

Figure 11 shows erratic but increasing operating torque during bottom drilling and reaming process. The torque developed while reaming the hole was an indicator that situation may get worse if non rotational drilling by mud motor was to be initiated. From figure 12, the average rate of penetration (ROP) was found to be 2.94m/h, an indication of a hard formation. Figure 13 indicates fairly high weight on bit (WOB) during formation drilling and slacked weight on string during reaming process prior to kick off. The flow line pressure indicates rising values (figure 14) shortly before well logging was commenced. That the string got stuck while logging was in progress, is a confirmation to hole pack off situation especially when other discussed factors are put into consideration.

3.1.1 Preventive Measures

Before running in hole new bit, there ought to have been wiper trip to casing shoe in order to confirm hole condition in terms of cuttings quantity. While tripping in new bit, reaming should have begun at least three stands to bottom. After well reaming, use of maximum circulation velocity was necessary in addition to sweeping the hole with weighted pills. Adequate circulation time and confirmation by use of hole cleaning chart could have changed the course of events. It is therefore very important to check at all times that the hole is cleared effectively by the mud. Monitoring cuttings at the shale shakers is also helpful [2].



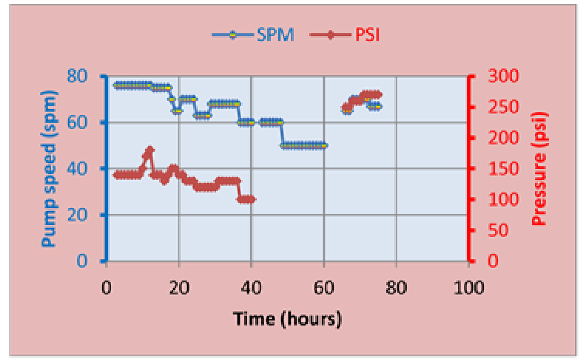


Fig. 13 Performance of bit weight and string rotation. **Fig. 14 Pump stroke vs. output flow line pressure**

3.2 OWECD Cause -Ledges & Doglegs

This hole had been previously drilled to 453m with positive mud returns and cased at 444.31m. The drilling on cement (DOC) was conducted using slick BHA to a formation depth of 550m after which the BHA was changed to angle building. The wiper trip was run to sound hole bottom and confirmed the well to be free of cuttings. On formation drilling, the drill string got stuck at 568m. At this point, 124m had been drilled before the drill string got stuck and snapped in less than an hour while trying to free it. Figure 15 shows erratic course through which the bit penetrated different formations, a situation that was characterized by alternating high and low rates of penetration.

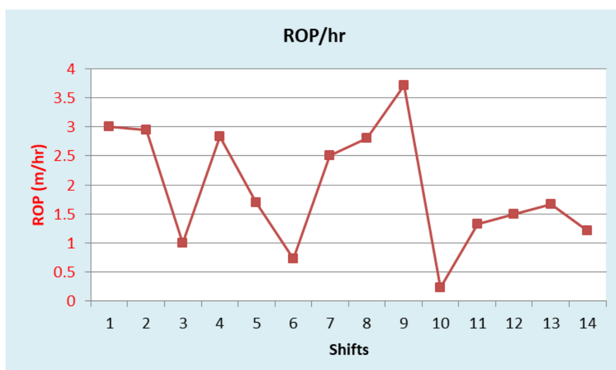
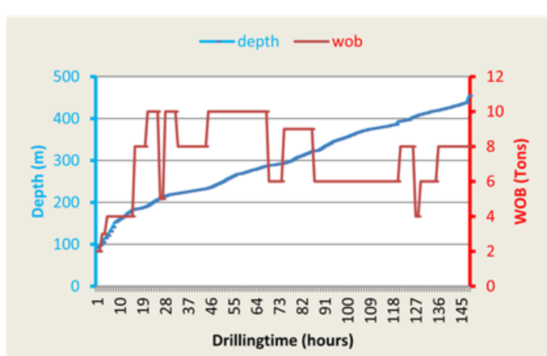


Fig. 15 Rate of penetration per 12-hour shift

Figure 16 shows the continuous bottom drilling and the corresponding WOB which exhibited erratic behavior within the range of 10 tons at maximum and 2 tons on the minimum. This is seen to be in tandem with changing degrees of rock hardness as sampled through lithological analysis. The string rotation was largely constant at 50 rpm over the same period as shown in figure 17.



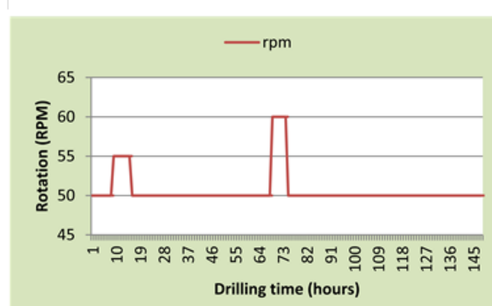


Fig. 16 Depth progression relative to WOB. **Fig. 17 String rotation with drilling time**

Between the depths of 450m to 570m, a range within which the drill string was stuck, the alternating medium hard and medium soft formation of basalt and tuff bearing clays, quartz, calcite and pyrite was depicted. Based on the drilling data and that of formation as described, it is indicative that dog legs could have developed as rate of penetration (ROP) erratically changed through varying rock hardness. The immediate failure of the drill string as soon as string pick up was attempted is another indicator to that fact as string over pull occasioned by dog legging of the hole was very likely. Excessive dog-legs cause key seats, rotating torque and trip drags among other hole problems. The occurrence of dog leg profile leads to rapid change of drill string tension and compression every 1/2 turn which accelerates fatigue wear [4].

3.2.1 Possible Remedies

When running in hole, it is essentially important to do so in such a manner that at no point is more than the BHA weight slacked off at a tight spot. In this case, the guidelines as prescribed by the stuck pipe handbook [2] are that, making use of minimal BHA configuration changes is critical. Frequent reaming of the hole section is highly recommended and avoidance of prolonged circulation across soft overlaid formations. In the planning of directional wells, dog-leg control programme should be included and dog-leg limits established to prevent drill pipe fatigue. The driller should be advised on the maximum dogleg tolerances at respective depth intervals [4]. .

3.3 OWECD Cause - Cement Blocks

This hole had been drilled to 855m with full circulation returns and later cased at 852.59m. After cementing, the top of cement was tagged at 607m and DOC thereafter. A cement column of 248m had been drilled using water before changing to aerated water and foam on bottom drilling. At 871m, the drill string was stuck i.e. 18.4m below the casing shoe. In view of the cement column that had to be drilled, the hard cement blocks that had caked along the casing wall was possibly dislodged by the string vibrations and settled above bit, hence the cause to stuck string. Figure 18 illustrates the gradual rise of the string torque as the bottom drilling progressed to 871m. The instant rise of torque at or near the stuck point demonstrates the possibility of build-up load of uncleared cement and formation cuttings around the bottom hole assembly.

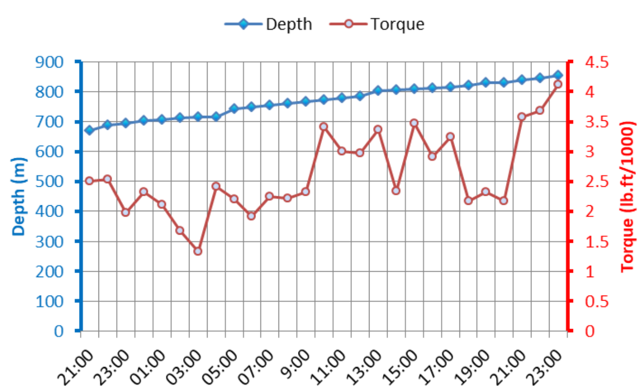


Fig. 18 Depth/Torque relationship before stuck pipe

3.3.1 Remedies

Application of the right cement slurry properties and accurate annulus volume calculations that limit the casing rat hole length to minimise the source of cement blocks. Sufficient curing time for cement before attempting to drill out must be strictly observed. Tripping in hole the slick BHA for drilling out cement should be conducted at relatively slow speeds prior to casing shoe depth or the plug depth. Reaming the casing shoe and open hole plugs thoroughly before drilling ahead is extremely necessary [6].

3.4 OWDE – Cause Reactive Formations

This well had been drilled to 764m, after which circulation was conducted for three hours. While POOH, there was detected resistance to upwards movement of the string at 40m above bottom. Circulation to unload the wellbore was undertaken and constant fluctuations in pump pressure were noticed. One hour later, while still circulating, an over-pull of 40k lbs. was observed. As efforts to unstuck the drill string progressed, the aerated water and foam was introduced but no circulation return was achieved.

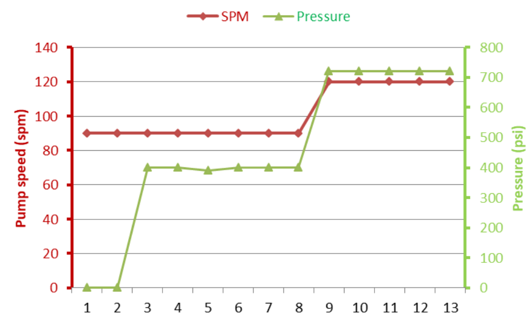


Fig. 19 Water pump speed and corresponding flowline pressure

3.4.1 Remedies

In this instance, drilling through chemically reactive formations which seems to be the case here required the right concentration of inhibition additives in oil-based mud (OBM) and water-based mud (WBM) such as salts (KCl, CaCL), glycol and polymer. [2] When shale absorbs water and swells into the well bore, it narrows down the hole diameter and make it very difficult to POOH. This happens when drilling with an incorrect mud specification. The use of inhibited mud system could have been helpful and consistently maintaining the mud properties. The addition of various salts (potassium, sodium, calcium, etc.) could have reduced the chemical attraction of water to the shale. Several wiper trips or reaming may have helped in the event that the shales started swelling. The frequency should be based on exposure time or warning signs of reactive shales and ensuring that the hole is adequately cleaned to remove excess clay balls and low gravity solids [2],[3].

3.5 OWDE – Cause Mobile Formations

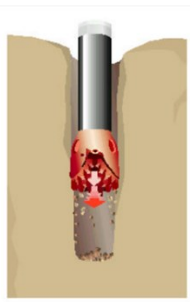
At a depth of 256m, it was practically impossible to continue on bottom drilling due to high torques and drags developed. The reaming of the well was begun from 242m to bottom. After pipe make-up, there was tag on obstruction at 231m. After one more hour into circulation, an obstruction was encountered at 220m. Further circulation was continued but encountered an obstruction at 231m, a point at which pipe connection was not possible. After ten hours of circulation, a failed attempt to make a pipe connection was made. This was due to an obstruction detected at 241m. Even after further circulation, there was an obstruction detected at 228m and eventually the drill string got stuck at 242m. The most likely cause of this stuck pipe incident was as a result of mobile formation than the collapsing formation. In this scenario, the mobile formation would squeeze into the well bore due to overburden forces compressing it. Mobile formations behave in a plastic manner, deforming under pressure. The deformation results in a decrease in the well bore size, causing problems running BHA and pipe connection. [2], [7].

3.5.1 Remedies

At well planning stage, the anticipated shales should be properly analyzed in view of suitable drilling fluid that must be based on the shale inhibition capability, correct mud weight and good hole cleaning design. An accurate understanding of the nature of shales that will be encountered is critical to the success of designing a high performance water-based mud system [7]. Selections of the appropriate mud system that will help avoid the aggravation of the mobile formation. Frequent reaming/wiper trips for this section of the hole were of absolute necessity. In such cases, close monitoring of swab and surge pressures and drilling fluid properties is paramount.

3.6 OWE0C Cause - Under-gauge Hole

After attaining 1275m, there was change of drill bit. The previous bit (re-run) had drilled 95m in 50 hours with positive circulation returns. While R.I.H new bit, there was experienced a sudden set down weight at 1208m and shortly after, while circulating prior to initiating reaming process, the drill string got stuck.



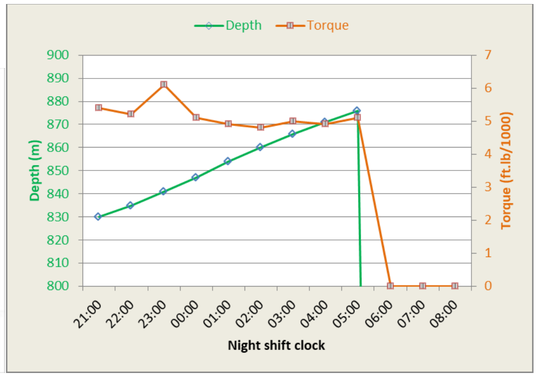


Fig. 20 Illustration of a tight hole [2] **Fig. 21 Drilled depth vs. corresponding torque**

Drilling a long column of hole or drilling through hard abrasive rock wears the bit and the stabiliser gauge and results in a smaller than gauge hole. Figure 20 is an illustration of a tight hole. The working torque with respect to depth progression before change of bit is shown in figure 21.

3.6.1 Remedies

Estimation of the possible occurrence of under gauge hole based on the bit condition as soon as it's been tripped out of hole is very important. Slow trip in of drill string before BHA enters an under gauge section is highly advisable. Reaming of the hole could have been initiated as early as possible from the point of projected under-gauge section. The use of under gauge roller reamer is worth consideration in such situations.

3.7 OWH0GB Cause - Unconsolidated Formation

In the course of drilling of this well at the depth of 185m, the drill string got stuck while making up drill pipe. The crew managed to free the string after six hours of efforts. At a depth of 204m, there occurred another stuck pipe incident which lasted for one hour. The bottom drilling progressed with relatively high torques to 290m when the drill string got stuck again. There had been observed substantial amount of particles and sand with increased mud weight. While the circulation returns was partially received on the surface, there can be seen non uniform ROP possibly due to changing formation as seen in figure 22.

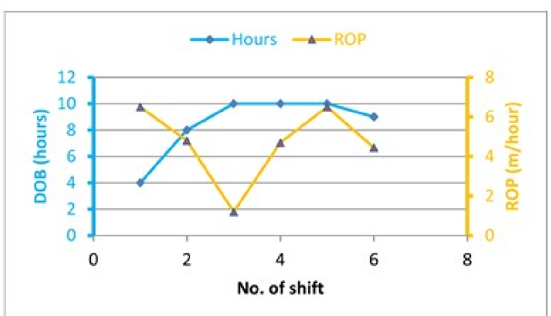


Fig. 22 Rate of penetration in relation to drilling hours **Fig. 23 Illustration of unconsolidated formation [8].**

In the three instances of stuck pipe at 185m, 204m and 290m, the hole pack-off due to unconsolidated formation is the most probable cause. This usually happens when little or no filter cake is present as illustrated in figure 23. The un-bonded formation cannot be supported by hydrostatic overbalance as the fluid simply flows into the formation. Sand or gravel then falls into the hole and packs off the drill string [8].

3.7.1 Remedies

Use of high vis/weight sweep to clean the hole off cuttings.The establishment of adequate filter cake to help stabilise the formation would have been a better approach. Seepage loss can be minimised with fine lost circulation material. There could have been controlled rate of penetration in the suspected zone to allow time for the filter cake to build up. Control of surge pressure by starting and stopping pumps slowly and slow working of the string is necessary too in such conditions [9].

3.8 OWI0EB Cause - Differential Sticking

In this case, the hole had been drilled to 748m with aerated water & foam. Circulation returns was received on the surface. Afterwards, the BHA was changed from kick-off to angle building, with new bit and two stabilizers. While tripping in hole new drilling assembly, an obstruction was encountered at 672m, i.e. 76m above the drilled depth. Reaming of the hole was proceeded with intermittent repair works of booster compressor for further 42 hours. The bottom drilling resumed and lasted for 13 hours with positive circulation returns. The drilled depth was 811m at rate of penetration (ROP) of 5.27m/hr. At a depth of 811m, the drill string got stuck immediately after the pipe connection. The string could not be rotated but could slightly be worked up and down. The string was suspended at 420 ton hook load, closed the pipe-ram and annular BOP and maintained the pressure at 600 psi in the drill string for three hours. After opening the rams, the well discharged and there was immediate drop in hook load from 420 tons to 160 tons. The string was finally free after 28 hours.

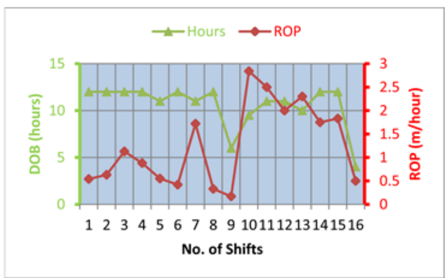


Fig. 24 ROP trend with shifts

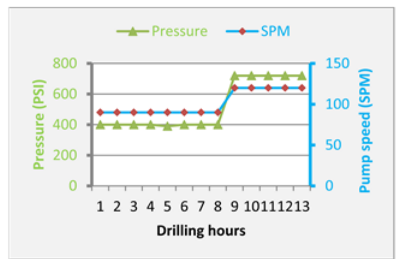


Fig. 25 Pump speed & pressure output values

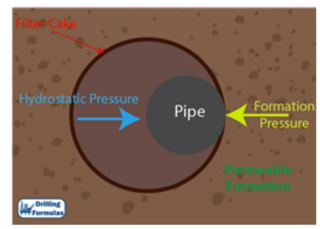


Fig. 26 shows differential sticking [5]

Figure 24 indicates the fluctuating but rising torque with drilling time. The pump strokes seems to have been increased at some point and corresponding rise in stand pipe pressure realized as figure 25 shows. Following the flow of events, differential sticking (mud weight in the hole being more than formation pressure) was the most likely cause to this stuck pipe incident. Having the drill pipe stationary during the pipe connection might have led to filter cake developing around permeable zones and the drill string, thus increasing the potential of getting differentially stuck as figure 26 illustrates. [2],[4].

3.8.1 Remedies

Differential sticking occurs when the drill string is held against the well bore due to pressure difference between hydrostatic and pore pressure. At the first signs of the drill string torqueing up, the pump strokes should be reduced by half [8]. This leads to pressure drop in the event of hole pack-off. The weight of mud is best kept at the required minimum for hole stability and for reduction of filter cake thickness in high formation pressure zones, and reduction of down time while making up pipe connections and deviation survey runs[10],[11].

4. CONCLUSION

Drilling activity is a process that requires more than an average attention. Based on the study reported in this paper, some of the conclusions drawn were: Hole cleaning practices were not properly adhered to hence leading to most stuck pipe at 45.95%. Generally, the mechanical related pipe sticking contributed to a total of 81.09%, formation related instability at 13.52% and differential pipe sticking at 5.41%. Machinery and equipment failure as well contributed substantially to stuck pipe occurrence. Importantly to note is that, there seemed to be persistent lack of alertness and error of judgment of the prevailing hole conditions on the part of the drilling crew, thereby missing out to pick-up indicators to stuck pipe. As has been argued elsewhere in this paper, the best solution to stuck pipe incidents is to avoid it as much as is practicably possible. This is achievable by exercising extreme attention to hole conditions at every step of the drilling process.

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