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Drag Analysis of Bottom Hole Assembly With Varying Friction Factors

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Abstract - *With each passing year, the exploration process is becoming more technologically advanced and increased complexity in the well profile. The increase in the complexity of the well will increase the chances of the failure of the BHA (Bottom Hole Assembly). Simulation of the critical parameter Like torque and drag, hydraulics, surge and swab, becoming more complex in this scenario. This will ensure that the factors are under the safety limits of BHA material. In this work we have designed and analyze the exploratory well of offshore on the basis of drag forces by varying the friction factors. We have compared the planned and actual well profile, so that the well planner will have the range of the friction factor while planning the offset well for the same field and by considering the friction factors it can select the BHA material for the operation.*

Key Words**: (Pick Up Drag, Slack Off Drag, Rotating On Bottom, Rotating Off Bottom, Tripping In, Tripping Out)**

1. INTRODUCTION

In the earliest days of land drilling most wells were drilled vertically straight down into the reservoir. Although these wells were considered to be vertical, they rarely were. Some deviations in the wellbore will always occur, due to formation effects and the bending of the drill string. In the directional wells the string tends to contact due to the tortuosity of the well and due to the gravity that makes the drill string to touch the inner surface of the wellbore, these contact between the drill string and the wellbore is defined in terms of drag which is based on the friction factors. it can also be termed as the force required to move the string up and down in the hole, pick up drag is usually higher than free rotating weight, while the slack off weight will always lower than the free rotating weight , the drag force is used to overcome the axial friction in the well, this phenomena is used in the deviated wells. We have also considered the contact associated with the casing of previous section while drilling for the next section, like during the drilling of 8.5" section, the contact of string associated with the 9-5/8" casing.

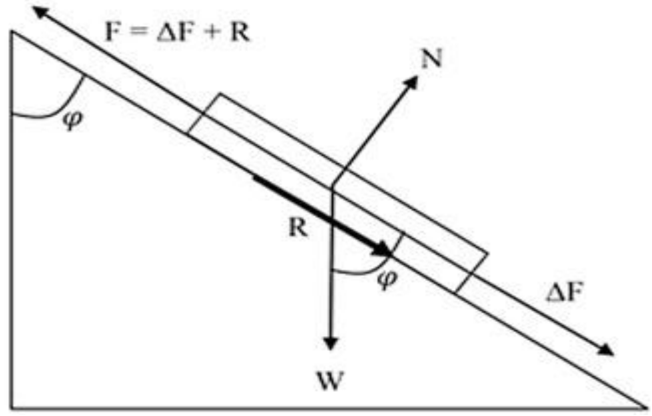

Fig:-1: Friction in Deviated Wells

To reduce the drag forces some adjustments to the well might reduce the forces (Maehs et al. 2010)[7]. While planning the well, the engineer has to maintain the friction limit under which can reduce the drag forces. The top drive of drive of either a deep-water floaters or a jack up rigs can easily reach their limitations, thus every method which reduces the drag forces and surface torque is always welcome. Following table shows the friction factor range as per the mud types.[8]

Mud Type	Casing Friction Factor	Open Hole Friction Factor
Oil Based	0.16 – 0.20	0.17 – 0.25
Water Based	0.25-0.35	0.25-0.40
Brine	0.30-0.40	0.3-0.4
Polymer	0.15-0.22	0.20-0.30
Foam	0.30-0.40	0.35-0.55
Air	0.35-0.55	0.40-0.60

Table-1:-Friction Factor Range [8]

To have accurate results of the analyses, it is very important to have a correct value of the friction factor (Mohammed Shehata Farhat , 2016)[1]. The torque and drag analyses originally started by the work of Johancsik et.al (1985). Because of the simplicity and being user friendly, his work has been used in the field and industries applications, he assumed that both the torque and drag is purely caused by the sliding friction forces, but this is not necessary, because the gravity and other factors that causes the drill string to contact the borehole. Schamp et al (2006), suggested some industrial methods to reduce the torque and drag in the wellbore during drilling. Rae et al (2005) [5], he used the simulator to firstly plan a well and then used it to calculate the torque and drag, the planned value is compared with the actual field data, if the values matched, it meant that the well is drilled as it was planned, otherwise, there was a problem either with planning or the with the drilling process.

1.1 Well Program

The location of the exploratory well AS-2#6H is in the azimuth of 221° with a horizontal drift of 1250m at the top of the producing layer of the reservoir from AS-2 Platform. It was planned that the different section of the well would drill with the different deviating tool.

2. Initial Design Phase

The well was designed with the DLS of 2.2°/100 ft; the KOP set at 140m from the MSL, the reason for the well to set the KOP of 140m is that, the formation is not hard enough to set the KOP below that. The BHA is also designed as for different section, based on the directional tool and different components as required for the operations.

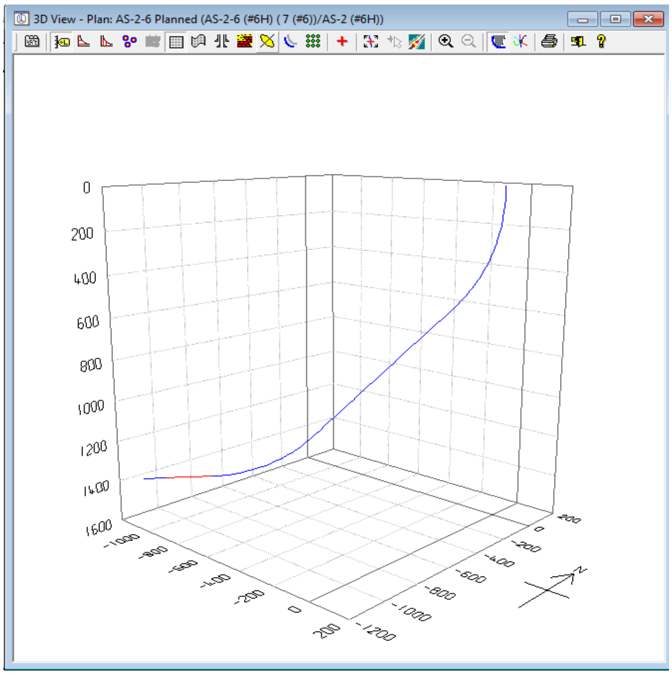

Fig:-2: 3D View of Planned Profile

The above 3D view shows the total TVD. In the planning stage the MD of the well was 2282m (MD-MSL).when the planned well was compared with the actual well, it was found that the actual well was drilled 108m more than the planned, which is because to explore more area of the producing zone.

2.1 Anti-collision Analysis

At the designing stage we have done the anti-collision analysis, in which the separation factors was found to be well above 2, which means that there will not be any collision issue during the drilling, if separation factor is less than 2 then it will be a case of collision, where the uncertainty envelopes overlaps, if the SF is equal to 2, then the uncertainty envelopes touches. But in this case the SF of the well ensures the positive inter boundary separation.

The ellipse of uncertainty places an important role while calculating the separation factor, because the different survey tools with different tool codes will have different ellipse of error, if the tool code with proper correction factor has not assigned to the wells, then while analyzing the anti-collision, the system will generate the collision issue with the nearby wells. The platform AS-2 has 12 slots, in which four slots were drilled which is indicated by different colors in the given figure.

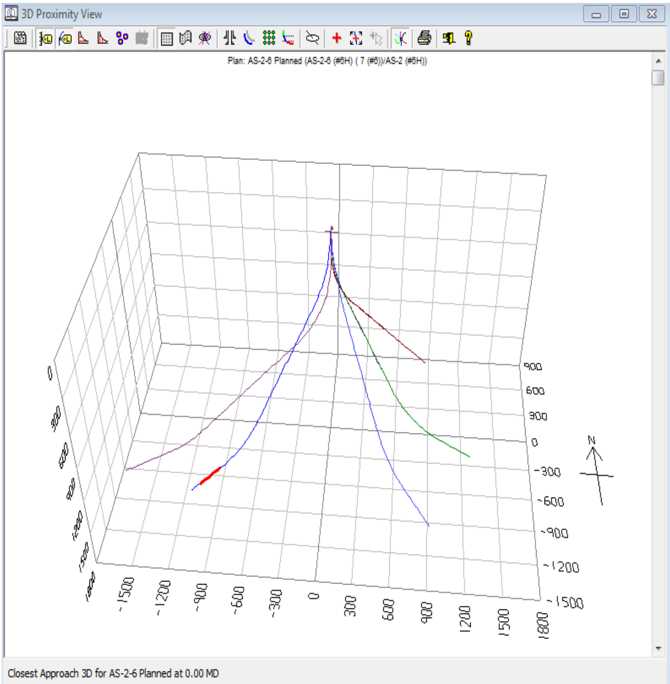

Fig:-3: Anticollision Analysis

3. Analysis of Drag Forces

As we have discussed in the introduction section that the drag forces are generated due to the contact forces between the drill string and the wellbore, the drag force always acts in the opposite direction of motion. The string does not slide down the inclined plane because of the drag force. The magnitude of the drag force depends on the normal force, and the coefficient of friction between the inclined plane, and the string. The coefficient of friction is a means to define the friction between the wellbore wall and the string. These contact may occur during the different drilling modes are under the action, like tripping in, tripping out, Rotating on Bottom, Rotating off Bottom.

The viscous drag is the additional drag force acting on the string due to the hydraulic effect while tripping in or rotating, Referring to drag which is the cumulative force required to trip in and trip out pipe, which are experienced along the axial direction of the pipe, the drag can be comparable to the hook loads (weight of the string measured at the surface), measuring from the rotating string weight, the pickup drag can be potentially greater than the slack off drag, following are the equation describe how pick up and slack off drag is estimated while tripping operations.

(1) Pick up Drag:- Tripping Out Weight – Rotating off bottom weight.

(2) Slack Off Bottom:- Rotating off Bottom weight-Tripping in weight.

3.1 Pickup Drag Chart

We have calculated the drag forces for different section as shown in figure. The given figure indicate the pickup drag forces with the friction factor range of 0.2- 0.3, the graph indicates that, with the increase in the friction factor, considerable drag forces also increases. The graph compares the actual and planned profile for the 12.25" section of the well, we have also calculated the drag for the 0.4 friction factor.. The difference in the actual and the planned drag curves will shows that, during planning of the offset well we should consider the friction range to be in the range of 0.2 – 0.3, because the actual drag curve for the set range of friction factor almost close enough to the planned drag curve. This means that, while planning the offset wells the materials or grade for the BHA can be selected on the basis of such drag forces, which should not fail during the drilling operation.

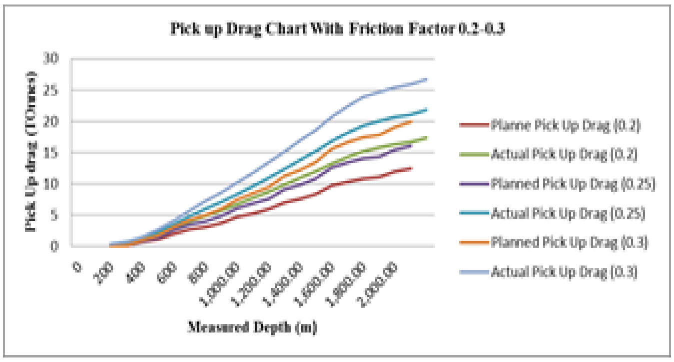

Fig -4: Drag Chart For 12.25" Section

There is no point of planning the well using friction values of 0.4, because the actual profile shows the wide range of variations when compared with the planned profile.

3.2 Slack off Drag Chart

The slack off drag chart is also set for the same range of friction factor, because it also shows that the curves for the planned and actual slack off drag forces will almost same.

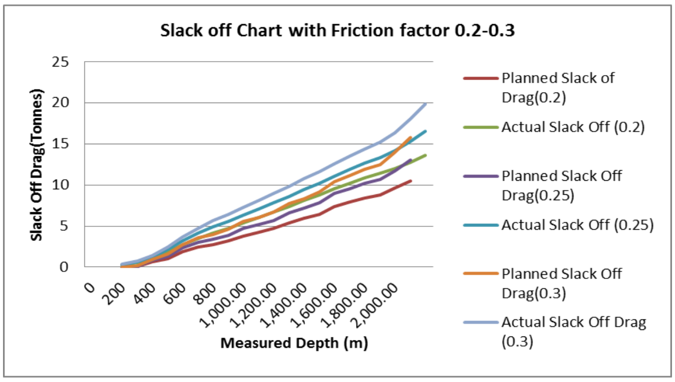

Fig:-5: Slack Off Drag Chart for 12.25" Section

Similarly, we have also calculated the drag forces for the 17.5" and 8.5" section of the well by setting the same friction factor range, the pickup and slack off drag shows the same results as we got for the 12.25" section of the well.

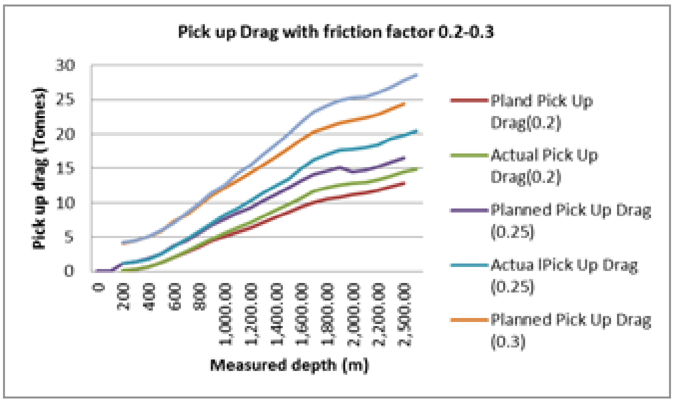

Fig-6:-Pick up Drag chart for 8.5" section

The above graph is for the 8.5"section of the well, in this section there the build rate was high and it has got curved section in the well path, which is inclined up to 90°, due to such a high angle the string tends to touch the inner surfaces of the wellbore and causing high drag, which is shown in the graph. The pumping rate for this section was kept 480gpm which is high enough to cause a viscous drag. The RSS assembly was recommended for this section so as to reduce the drag forces, if we would have used the mud motor assembly. We would have got more drag forces because of the bent sub, the bent sub generates a more tortuosity than with RSS, this is due to the steering principle of such tools and it also results in increase in the hole size. As 12.25" section, we have also calculated the drag forces by keeping the friction values 0.4, in which the curves for the planned and actual is showing the wide gap, so this is not recommended for the offset wells.

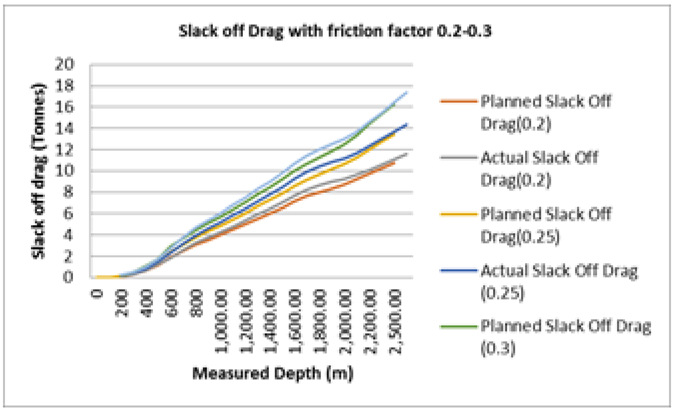

Fig-7:-Slack of Drag Chart for 8.5" section

The above graph shows the slack off drag for the 8.5" section of the well, in which not much of the variation involved between planned and actual curves of drag at different friction factor values.

4. CONCLUSIONS

- Survey Details

Parameters	Section of the well		
	17.5"	12.25"	8.5"
MD Start (m)	235	1227	2102
MD Ends (m)	1188	2104.32	2425
Previous Casing	20"	13-3/8"	9-5/8"
Mud Wt (ppg)	10	11	8.1
Mud Types	SOBM	SOBM	Water based
Drilling Mode	SDMM+MWD	SDMM+MWD	RSS+LWD

- The comparison on the planned and actual data is done of the offshore field, which shows that the dogleg of the actual well profile will remains the same as for the planned profile, but, there will definite change in the measured depth of the actual well.
- Wellbore friction is a critical parameter not only to drill oil wells, but also during casing running, running in casing in horizontal wells is usually one of the most critical operations.
- The results of the work shows that the range of the friction can be set on 0.20 to 0.30 while planning for the offset wells from the same field Since Proper calibration is required to determine the true value for the friction coefficient including the drill string rotation effect.
- The analysis shows that the material or grades which Are used in the BHA is lying well under the safety limits.

Nomenclature

BHA- Bottom Hole Assembly
KOP- Kick of Point
DLS-Dog-Leg Severity(Degree/100m)
MSL- Mean Sea Level
TVD- Total Vertical Depth
MD- Measured Depth
SF- Separation Factor

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