Modeling of torque and drag in directional oil well in Garaf oil field

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Abstract - Torque and Drag is one of the most significant problems associated with extended reach or horizontal drilling is torque and drag which is caused by the friction between the drill string and the wall of the hole. The magnitude of the torque and drag is determined by the magnitude with which the pipe contacts the hole wall and the friction coefficient between the wall and pipe. The main factors that effect on Torque and Drag are; friction coefficient, Change the directional profile, string weight or tension.

The most important data that were relied upon are: WELLBORE DESCRIPTION, FRICTION COEFFICIENT and SURVEY OUTPUTS SECTION (Measured Depth, Inclination, Azimuth and Dog-Leg Severity), Bit Depth, Tripping Load Data, Cased Hole Translational (Slide) Open Hole Translational (Slide) Cased Hole Rotational Open Hole Rotational Cased Hole Translational (Ream) Open Hole Translational (Ream) and many other important data. And the solution method that was dealt with this data is Excel Sheet.

This study resulted in ability to quickly calculate the torque and drag magnitudes of wellbores for a particular well path trajectory and BHA. The advantage of this method is the implementation of linear interpolation for every 1-m interval on the inclination, azimuth and unit weight of the BHA for torque and drag calculations. This model allows users to easily conduct torque and drag calculations by using MS Excel program package due to its user-friendly interface. Previous models analyzed the string by dividing into sections of 30 m.

The friction analysis inside the wellbore should be carefully performed. Correct assessment of buoyancy and the effect of the well path are shown to be critical for calibrating the friction coefficient.

Keyword:

- Torque

- Drag

- Buckling

- Hookload

I. Introduction

1 Torque and Drag concept:

When a drilled borehole deviates from the true vertical direction, the contact between the drill string and drill hole generates frictional forces and normal forces. These frictional and normal forces oppose the direction of drill string motion, arising to the effects of torque and drag. Drag is defined as the additional force required for moving the pipe up or down in the borehole as a result of the generated frictional forces and contact loads, while torque is the additional moment force required to rotate the pipe [6].

Knowledge of torque and drag will enable the selection of an optimum well profile and optimum size and weight of the drill string and its components, and it can Identify problem areas, establish mud program needs the effectiveness of hole actions, the torque and drag can provide the ability to Determining reaming, backreaming and short trip requirements and also Can simulate drilling and also completion (casing) runs.[7]

2. Model for torque and drag:

Drag and torque in deviated wells are the most important two parameters which is required to be taken into consideration in addition to weight on bit, work string rotation. In deviated wells torque and drag are assumed to be entirely due to the frictional forces that result from the drill string and wellbore contact. The calculation methodology representation of the bottom hole assembly (BHA) items in a wellbore is given in Figure 1. The segment items are taken at 1 m intervals. The azimuth and hole deviation along each and every 1 m is linearly interpolated accordingly, and used in the calculation for each 1 m segment of the BHA. The drag and torque calculations are conducted for each segment, starting at the bottom of the drill string and moving upwards towards surface. The axial and torsional load for each segment contributes increasing magnitudes towards the top of the string as a function of the wellbore geometry.

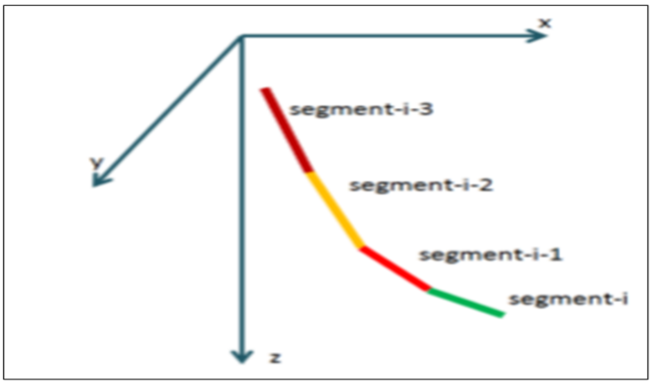


Figure 1. Calculation methodology

Note: This sketch depicts the calculation methodology of BHA items inside a deviated wellbore

3. The Components of Torque & Drag:

Frictional and normal forces are a function of the drilling parameters and surfaces encountered. Drilling parameters that affect the coefficient of friction and normal forces include, but are not limited to, drilling mud properties, well path design, hole section surfaces encountered and tubular design. Surfaces encountered are usually simplified to contact between tubulars and casing in cased hole and contact between

tubulars and formations in open hole. Typical friction coefficients for cased hole and open hole while drilling with water-based mud are 0.25 and 0.35 respectively [7].

It is important to understand that the effects of torque and drag are also influenced by the mode that drilling is happening or the operation that is being conducted. With regards to the motion of the drill string, there are two drilling modes, sliding and rotating. Sliding is where the drill string is displaced axially up and down the drill hole, while rotating is where the drill pipe is rotated about a point in the drill hole. Sliding of the drill string greatly contributes to drag forces but minimal to torque, while the opposite is true for rotating of the drill string [8].

Other drilling operations include tripping in and out of the well. In order to effectively model torque and drag for drilling a well. [9] developed the soft string model, The soft string model assumes that the entire drill string lies against the low side of the wellbore meaning that the stiffness of the drill string is not accounted for.

For modelling purposes, the drill string is represented by a cable divided up into small elements that only carry axial loads and torque, while the contact forces are supported by the wellbore [10].

In addition to soft string modelling, stiff string models have been developed as an attempt to model a more realistic situation downhole. McCormack et al. [10] describe that stiff string models endeavor to do this by taking into account the stiffness and bending moment in the tubular and radial clearance in the wellbore that results. However, they also suggest that even though stiff string models incorporate more variables, it is not necessarily more accurate than a soft string model. The decision to choose between a soft string or stiff string model is dependent on the well situation. Stiff string models are more beneficial for wells that have high tortuous trajectories, high dogleg severity or stiff tubulars [10].

The effects of fluid flow on torque and drag modelling is varied and not taken into account by all models. Fluid flow during drilling results in the loss of the normal component of fluid pressure on the drill string as the static condition is broken. There is also an additional tangential component caused by viscous drag on the drill string due to the fluid flow [11]. The additional force due to viscous drag is calculated as follows [12]:

$$\Delta F = \frac{\Delta P \pi (D_h^2 - D_p^2) D_p}{4(D_h - D_p)}, \qquad \text{Equation (1)}$$

where F is the force (N), ΔP is the annular pressure loss based on rheological model selected (Pa), Dh is the diameter of the hole (m) and Dp is the diameter of the pipe (m). The determination of annular pressure loss for different rheological models has been already reported in Applied Drilling Engineering [13]. There is no direct calculation of viscous drag due to pipe rotation. The additional torque on the pipe due to viscous drag is calculated as follows [12]:

$$\Delta T = \tau_t 2\pi L \left(\frac{D_p}{2}\right)^2, \qquad \text{Equation (2)}$$

where T is the torque (N.m), τt is the shear stress based on the rheological model selected (Pa) and L is the length of the pipe (m). Further details about determination of shear stress for different rheological models can be found in Applied Drilling Engineering [13].

4. Area of Study:

Garraf oilfield is one of the important southern oilfields in Iraq, it is located in the province of Thi Qar, approximately 5km north-west of Al-Refaei city and 85km north of the city of Nasiriya.The field is 17.5km long and 5.5km wide. It is estimated to hold 1.3 billion barrels of oil reserves.

The first exploration activities in Garraf started back in 1976 until 1978, subsequent to the success of exploration and appraisal wells (Ga-1, Ga-2, Ga-3) a 2D seismic survey on Rafidain-Garraf was conducted by OEC in 1992 to further define the structures of Rafidain and Garraf structures.[15]

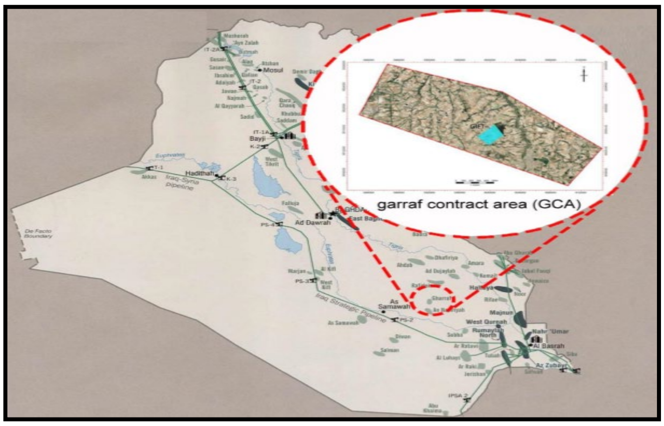


Figure 2. Garraf oilfield location [15]

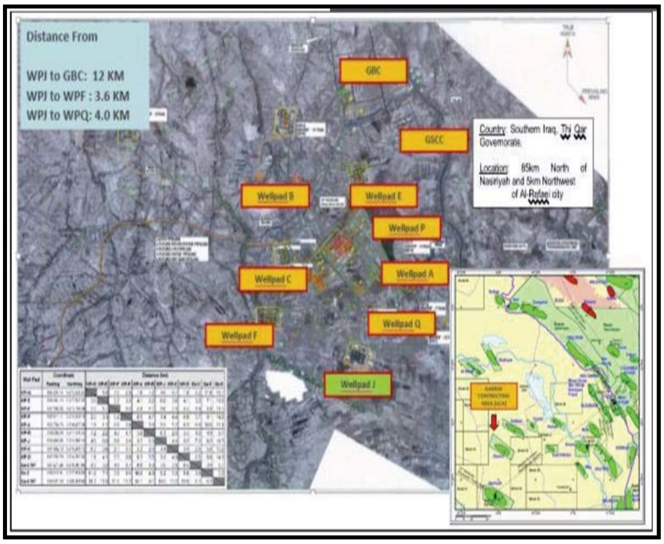


Figure 3. The Well pad location in Garraf oil field[14]

II. Methodology

friction is always present and will contribute to the force required to move the object. The friction force is equal to the normal force times the friction coefficient. Therefore, the force required to pull the block up the plane is:

{T = - W Sin (θ) + μ W Cos (θ)} Equation (3)

Where: T = Axial Tension

W = Buoyed Weight of Pipe

μ = Friction Coefficient

θ = Angle of Incline

The force required to push the block down the incline is:

{T = - W Sin (θ) - μ W Cos (θ)} Equation (4)

If θμcosW is greater thanθsinW, the object will have to be pushed down the incline. The same is true for pipe in a wellbore only the inclination is equal to 90° less the angle of the incline. The incline of the plane is measured from the horizontal but the inclination of a well is measured from the vertical. A perfectly vertical well has an inclination of 0º.

It should be remembered that the tension required to move the block is independent of surface area. For drill pipe, it is usually only the tool joints that touch the wall of the hole. However, it does not matter if just the tool joint or the entire pipe body is touching the wall, the drag values will be the same. It must also be remembered that friction is one body sliding over another body. If a portion of the drill string digs into the wall of the hole or the hole is dirty, it is no longer simple friction and torque and drag values will be higher. Torque and drag can be experienced in a vertical well if the hole is dirty.

SIMPLIFIED TORQUE AND DRAG MODEL

The friction coefficient depends upon the type of drilling fluid in the wellbore and the roughness of the wellbore walls. Cased hole should have a lower friction coefficient than open hole. Untreated water-based muds will have a higher friction coefficient than oil-based muds. Friction coefficients have been reported to range from 0.15 to 0.25 for oil-based muds and 0.25 to 0.40 for water-based muds. Clear brines will have higher friction coefficients usually between 0,30 and 0.40. Air drilling has the highest friction coefficients with friction coefficients between 0.40 and 0.50.

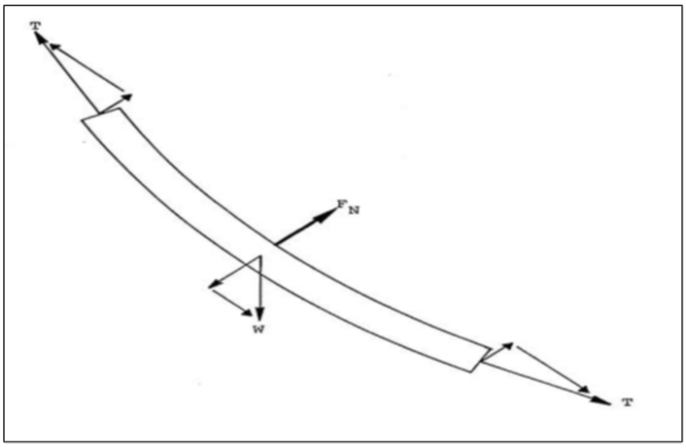


Figure 4. Forces on a Drill String Segment ΔL

In lower inclination wells, the drag associated with the inclination is relatively low. The inclination drag in high angle wells, horizontal wells and extended reach wells can be significant. When hole curvature is considered, an additional force is added to the normal force from the pipe weight and is the source of most of the drag experienced in directional wells. Pipe placed in a curved wellbore under tension will exert a force proportional to the tension and rate of curvature change (dogleg severity). Figure 1 shows the forces involved. The resultant normal force is the sum of the normal forces due to tension and pipe weight.

If the x-axis is assumed to be in the vertical plane and the y-axis is assumed to be in the horizontal plane along the axis of the hole, then summing the forces in the x and y direction will yield the normal forces:

$$F_x = 2T \sin\left(\frac{\Delta I}{2}\right) + W \sin I_{(avg)}$$ Equation (5)

The vectorial sum of the forces is the resultant normal force due to tension and is:

$$F_y = 2T \sin\left(\frac{\Delta A}{2}\right) \sin I_{(avg)}$$ Equation (6)

Calculating the normal force at each point along the drill string and multiplying by the friction coefficient will yield the increased tension caused by drag. The sum of the drag and weight will equal the drill string tension at any point in the well.

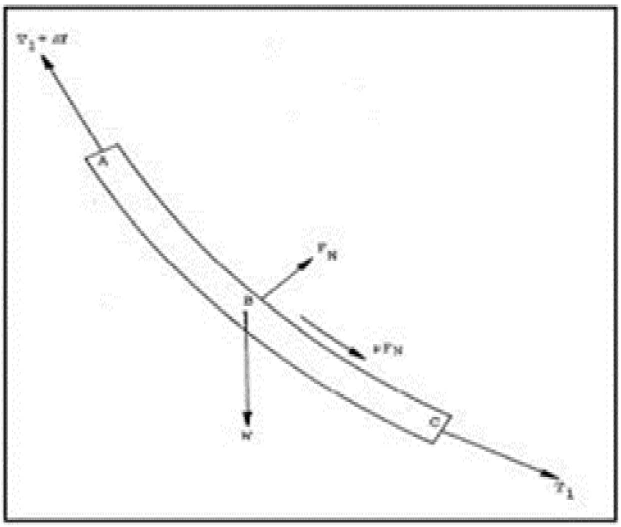


Figure 5. Forces Acting on the Drill String Segment ΔL while Pulling Out of the Hole.

In reality, the normal force changes at each point along the drill string segment: however, if is small enough, the normal force can be assumed to act at Point "B." The resulting error in the calculation of LΔLΔTΔ will be small and well within the accuracy of known conditions within the wellbore.

For more accurate calculations, the length of LΔ should not exceed 100 feet. Survey stations are usually closer than 100 feet, and the distance between the survey stations can be assumed as the length. LΔ Equation 6 and Equation 7 can be used to calculate the tension in the drill string. The calculation starts at some point of known tension. In most cases, the point of known tension is the bit where the tension is zero unless the bit is stuck. Drag always acts in the opposite direction that the drill string is moving. While tripping out, the drag will increase the tension in the string. While tripping in the hole, the drag will decrease the tension in the string.

Pulling out of the hole:

$$T_2 = T_1 - W \cos I_{(avg)} + \mu F_N$$ Equation (7)

Running in the hole:

$$T_2 = T_1 - W \cos I_{(avg)} - \mu F_N$$ Equation (8)

Buckling of the drill string while tripping in the hole causes an additional drag force. Dawson and Paslay1 derived an equation for the critical buckling load for sinusoidal buckling in an inclined hole. The critical buckling load is a function of the inclination, pipe size, and radial clearance. In reality, the pipe will experience helical buckling after the sinusoidal buckling and then the drag will increase. However, this is a simple torque and drag model and helical buckling will be ignored. Additionally, hole curvature will affect the critical buckling load.

Equation (9) (in basic units) is used to calculate the load at which pipe will buckle in an inclined well.

Equation (10) is in English oilfield units.

$$F_{crit} = 2\sqrt{\frac{EI\rho Ag \sin I}{r}} \quad \text{Equation (9)}$$

$$F_{crit} = \sqrt{\frac{9.82\times10^5 (OD^4 - ID^4)(W_f)B\sin I}{(D_h - OD)}} \quad \text{Equation (10)}$$

Once the compressive forces in the drill string exceed the critical buckling load, an additional normal force is imposed upon the drill string. This force must be added to the normal force caused by bending and tension (or compression).

For simplicity, it is assumed that the drill string will form a sine wave when it buckles which is probably not always the case in an inclined wellbore. Mitchell2 derived Equation 10 for calculating the wall contact force (normal force) caused by sinusoidal buckled tubing.

$$W_N = \frac{rF_f^2}{4EI} \quad \text{Equation (11)}$$

Buckling causes additional drag forces in sections of the well with no curvature including the vertical portion of the well.

The torque in a directional well can be calculated using the same equations for determining the normal force. The only difference is that hole drag is not considered. When the pipe is rotated, the drag forces are nullified and only the weight component and bit weight contribute to the tension in the drill string. If pipe movement is fast, all the drag forces are not nullified, so some drag will still be present when rotating pipe while tripping in the hole.

The normal force is calculated using Equation 6. While rotating, the tension at any point in the well is calculated using Equation 12.

$$T_2 = T_1 - W\cos I_{(avg)} \quad \text{Equation (12)}$$

The rotating weight would be the value of at the surface. 2T

The torque in the drill string is determined by the normal force. The normal force times the friction coefficient is the force resisting rotation of the drill string.

Again, the torque is calculated in segments ()LΔ along the drill string. Equation 13 is used to calculate the torque. The radius of the pipe, R, is used to calculate the torque. In most cases, only the drill pipe tool joint contacts the wall of the hole and the radius of the tool joint should be used to calculate the torque from the drill pipe.

$$M_2 = M_1 + \mu F_N R \quad \text{Equation (13)}$$

The torque and drag will increase as the tension and dogleg severity increases.

$$W = (Length)(W_f)(B) \quad \text{Equation (14)}$$

In normal directional wells, the drag while tripping out of the hole will be the major concern. The drag while tripping in the hole will not exceed the pipe weight until the critical inclination is reached. The critical inclination can be calculated using Equation 15. At that point, the pipe will have to be pushed into the hole. The difference can be substantial in an extended reach well or horizontal well.

$$I_c = \tan^{-1}\left(\frac{1}{\mu}\right) \quad \text{Equation (15)}$$

III. RESULTS

MAIN EQUSIONS USED IN CALCULATIONS

W= (L) (UF) (B)

T= (u) (FN)

FN= {2T Sin (dl/2) +W Sin I(avg)}

Data used-solved in this project by using excel sheet.

SECTION 26''

Table 1. wellbore description

Section Name	**Length**	**Cum Length**	**Diameter**
	m	m	in
30" Conductor	37.93	37.93	29.25
26" BHA Run	430.47	468.40	26.00
Mud weight = 9.3 ppg			

Table 2. friction coefficient

	Cased Hole Translational (Slide)	Open Hole Translational (Slide)	Cased Hole Rotational	Open Hole Rotational	Cased Hole Translational (Ream)	Open Hole Translational (Ream)
Base Set	0.2	0.3	0.2	0.3	0.05	0.05
Set 1	0.2	0.2	0.2	0.2	0.05	0.05
Set 2	0.3	0.3	0.3	0.3	0.05	0.05
Set 3	0.4	0.4	0.4	0.4	0.05	0.05
Set 4	0.5	0.5	0.5	0.5	0.05	0.05

Table 3. survey outputs section 26 in

Measured Depth	**Inclination**	**Azimuth**	**Dog-Leg Severity**
m	deg	deg	deg/30m
0.00	0.00	0.00	
21.60	0.11	111.75	0.15
31.60	0.12	291.75	0.69
41.60	0.09	111.75	0.63
51.60	0.07	291.75	0.47
61.60	0.02	291.75	0.13
71.60	0.03	291.75	0.03
81.60	0.12	111.75	0.46
91.60	0.02	291.75	0.42
101.60	0.10	291.75	0.24
111.60	0.14	291.75	0.13
121.60	0.15	111.75	0.87
131.60	0.11	291.75	0.78
141.60	0.01	111.75	0.38
151.60	0.13	291.75	0.42
161.60	0.10	111.75	0.68
171.60	0.08	291.75	0.53
181.60	0.13	291.75	0.17
191.60	0.02	291.75	0.34
201.60	0.05	291.75	0.09
211.60	0.11	291.75	0.17
221.60	0.12	111.75	0.70
231.60	0.01	111.75	0.34
241.60	0.06	291.75	0.22
251.60	0.10	111.75	0.48
261.60	0.11	291.75	0.61
271.60	0.14	291.75	0.09
281.60	0.12	111.75	0.78
291.60	0.10	111.75	0.08
301.60	0.11	111.75	0.03
311.60	0.04	291.75	0.45

321.60	0.05	111.75	0.27
331.60	0.04	291.75	0.28
341.60	0.10	111.75	0.43
351.60	0.11	291.75	0.63
361.60	0.01	291.75	0.30
371.60	0.13	291.75	0.37
381.60	0.01	111.75	0.42
391.60	0.02	291.75	0.08
401.60	0.03	291.75	0.05
411.60	0.03	111.75	0.18
421.60	0.11	111.75	0.25
431.60	0.03	291.75	0.42
441.60	0.08	291.75	0.14
451.60	0.11	291.75	0.09
461.60	0.12	111.75	0.68
471.60	0.02	111.75	0.28

Torque

Table 4. The first step is to divide the drill string into small elements from bottom to top as shown in below

Bit Depth	**Inclination**	**Azimuth**	**CSG 0.2 OPH 0.2**	**CSG 0.3 OPH 0.3**	**CSG 0.4 OPH 0.4**	**CSG 0.5 OPH 0.5**
m	deg	deg	1000 ft.lbf	1000 ft.lbf	1000 ft.lbf	1000 ft.lbf
0	0	0	0	0	0	0
30	0.1181 58771	291.75 10326	0	0	0	0
60	0.0225 00404	291.74 88866	0	0	0	0
90	0.0192 88271	291.74 96876	0.0029 75734	0.0044 63601	0.0059 51468	0.0074 39335
12 0	0.1454 14673	111.75 11104	0.0009 17363	0.0013 76044	0.0018 34726	0.0022 93407
15 0	0.1260 65174	291.75 01048	0.0029 28717	0.0043 93075	0.0058 57434	0.0073 21792
18 0	0.1344 91612	291.75 05451	0.0031 70225	0.0047 55337	0.0063 4045	0.0079 25562
21 0	0.1082 55382	291.75 10068	0.0019 10561	0.0028 65842	0.0038 21123	0.0047 76403
24 0	0.0627 22175	291.75 12958	0.0062 09307	0.0093 13961	0.0124 18614	0.0155 23268
27 0	0.1371 61737	291.75 03773	0.0101 60536	0.0152 40805	0.0203 21073	0.0254 01341
30 0	0.1063 748	111.74 92888	0.0072 01056	0.0108 01584	0.0144 02112	0.0180 0264
33 0	0.0449 20215	291.74 90729	0.0177 84615	0.0266 76922	0.0355 69229	0.0444 61537
36 0	0.0106 11175	291.74 8713	0.0087 66928	0.0131 50392	0.0175 33855	0.0219 17319
39 0	0.0172 46811	291.74 90732	0.0117 84361	0.0176 76542	0.0235 68723	0.0294 60904
42 0	0.1077 60831	111.75 0557	0.0169 94309	0.0254 91464	0.0339 88619	0.0424 85773
45 0	0.1101 30822	291.75 09701	0.0173 83798	0.0260 75698	0.0347 67597	0.0434 59496
48 0	0.0218 153	111.74 89407	0.0255 84188	0.0383 76282	0.0511 68376	0.0639 6047

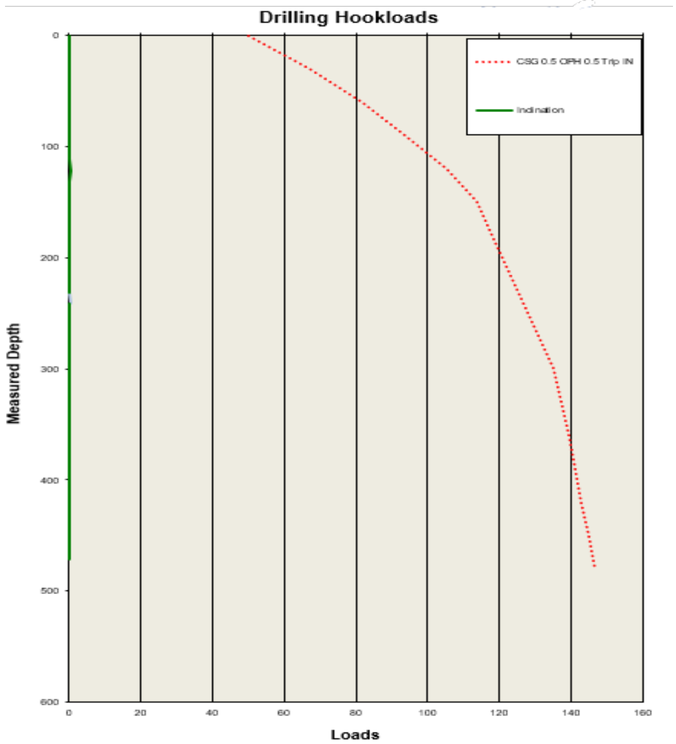
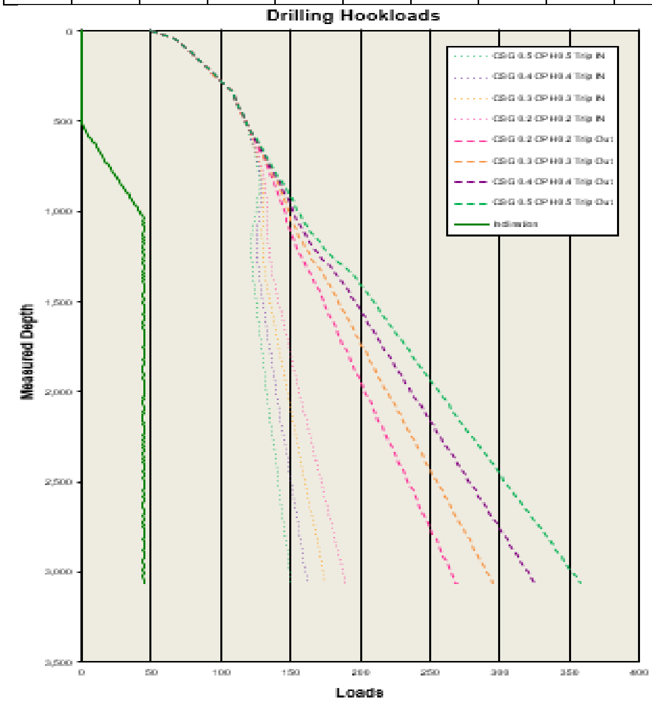


Figure 6. Drilling Load plot

Table 5. Tripping Load

Bit Depth	CSG 0.5 OPH 0.5 Trip IN	CSG 0.4 OPH 0.4 Trip IN	CSG 0.3 OPH 0.3 Trip IN	CSG 0.2 OPH 0.2 Trip IN	Rotate Off Bottom	CSG 0.2 OPH 0.2 Trip Out	CSG 0.3 OPH 0.3 Trip Out	CSG 0.4 OPH 0.4 Trip Out	CSG 0.5 OPH 0.5 Trip Out
m	1000 lbf	1000 lbf	1000 lbf	1000 lbf	1000 lbf	1000 lbf	1000 lbf	1000 lbf	1000 lbf
0.00	50.03	50.03	50.03	50.03	50.03	50.03	50.03	50.03	50.03
30.00	67.10	67.10	67.10	67.10	67.10	67.10	67.10	67.10	67.10
60.00	81.53	81.53	81.53	81.53	81.53	81.53	81.53	81.53	81.53
90.00	93.87	93.87	93.87	93.87	93.88	93.88	93.88	93.88	93.89
120.00	105.09	105.09	105.09	105.09	105.09	105.09	105.09	105.09	105.09
150.00	113.86	113.86	113.86	113.87	113.87	113.88	113.89	113.89	113.89
180.00	118.12	118.12	118.12	118.13	118.13	118.14	118.14	118.14	118.14
210.00	122.37	122.38	122.38	122.38	122.39	122.39	122.40	122.40	122.40
240.00	126.60	126.61	126.62	126.63	126.65	126.66	126.67	126.68	126.69
270.00	130.84	130.86	130.87	130.88	130.90	130.93	130.94	130.95	130.96
300.00	135.10	135.12	135.13	135.14	135.16	135.18	135.19	135.20	135.22
330.00	137.32	137.34	137.36	137.39	137.43	137.48	137.50	137.53	137.55
360.00	139.21	139.22	139.24	139.25	139.29	139.32	139.33	139.35	139.36
390.00	141.04	141.06	141.08	141.10	141.14	141.18	141.20	141.21	141.23
420.00	142.87	142.89	142.92	142.94	142.99	143.04	143.06	143.09	143.11
450.00	144.69	144.72	144.75	144.78	144.84	144.90	144.93	144.96	144.99
480.00	146.47	146.51	146.56	146.60	146.69	146.79	146.83	146.88	146.92



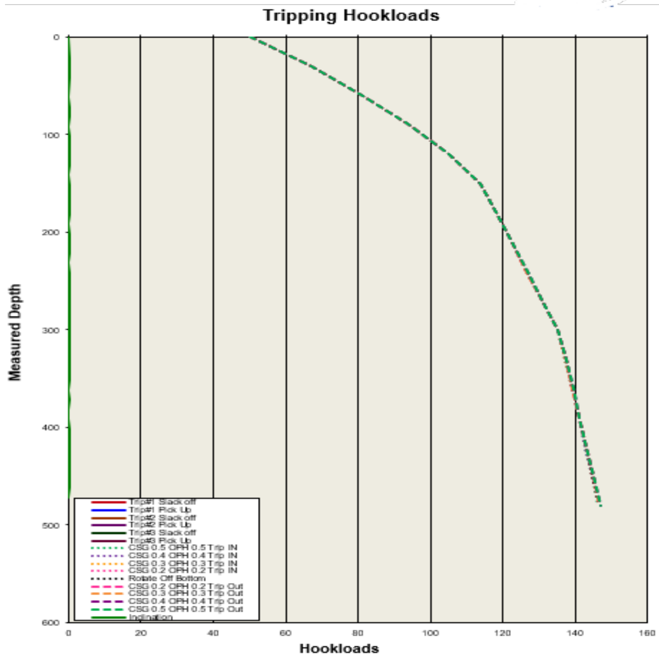


Figure 7. Tripping load plot

Table 6.

wellbore discribtion

Section Name	Length	Cum Length	Diameter
	m	m	in
18.625" Casing Run	468.40	468.40	17.76
17.5" BHA Run	1245.68	1714.08	17.50

Table 7. friction factors

	Cased Hole Translational (Slide)	Open Hole Translational (Slide)	Cased Hole Rotational	Open Hole Rotational	Cased Hole Translational (Ream)	Open Hole Translational (Ream)
Base Set	0.2	0.3	0.2	0.3	0.05	0.05
Set 1	0.2	0.2	0.2	0.2	0.05	0.05
Set 2	0.3	0.3	0.3	0.3	0.05	0.05
Set 3	0.4	0.4	0.4	0.4	0.05	0.05
Set 4	0.5	0.5	0.5	0.5	0.05	0.05

Table 8. survey outputs section 17.5 in

Measured Depth	Inclination	Azimuth	Dog-Leg Severity
m	deg	deg	deg/30m
0	0	0	
21.6	0.111468658	111.7512414	0.154817581
31.6	0.118158771	291.7510326	0.688882288
41.6	0.090429788	111.7506191	0.625765676
51.6	0.067139649	291.7491725	0.47270831
61.6	0.022500404	291.7488866	0.133917734
71.6	0.032511793	291.7491753	0.030034166
81.6	0.121499337	111.7510286	0.462033391
91.6	0.019288271	291.7496876	0.422362823
101.6	0.100812032	291.7504374	0.244571284
111.6	0.143424409	291.7496217	0.127837131
121.6	0.145414673	111.7511104	0.866517245
131.6	0.114120091	291.750989	0.778604292
141.6	0.012689314	111.7504761	0.380428217
151.6	0.126065174	291.7501048	0.416263464
161.6	0.100094455	111.7494217	0.678478887
171.6	0.077449476	291.7488086	0.532631793
181.6	0.134491612	291.7505451	0.171126409
191.6	0.021519563	291.7498097	0.338916146
201.6	0.052874866	291.7496268	0.094065907
211.6	0.108255382	291.7510068	0.16614155
221.6	0.123900923	111.7508867	0.696468917
231.6	0.01002141	111.7507198	0.341638541
241.6	0.062722175	291.7512958	0.218230756
251.6	0.096801669	111.7496519	0.478571533
261.6	0.105851827	291.7506675	0.607960487
271.6	0.137161737	291.7503773	0.093929731
281.6	0.123611235	111.7491653	0.782318915
291.6	0.096895194	111.7511713	0.080148122
301.6	0.1063748	111.7492888	0.02843882
311.6	0.044366788	291.749004	0.452224765
321.6	0.047008059	111.7506183	0.274124541
331.6	0.044920215	291.7490729	0.27578482
341.6	0.099865723	111.7495986	0.434357812
351.6	0.110010595	291.7492062	0.629628954
361.6	0.010611175	291.748713	0.29819826
371.6	0.13291995	291.7508024	0.366926324
381.6	0.00837351	111.7490506	0.423880381
391.6	0.017246811	291.7490732	0.076860963

401.6	0.032777782	291.7495933	0.046592913
411.6	0.026057142	111.750124	0.176504771
421.6	0.107760831	111.750557	0.245111065

TABLE 9. SECTION 12.25"

WELLBORE DESCRIPTION

Section Name	Length	Cum Length	Diameter
	m	m	in
13.375" Casing Run	1714.08	1714.08	12.42
12.25" BHA Run	1338.57	3052.65	12.25

Table 10. friction factors

	Cased Hole Translational (Slide)	Open Hole Translational (Slide)	Cased Hole Rotational	Open Hole Rotational	Cased Hole Translational (Ream)	Open Hole Translational (Ream)
Base Set	0.2	0.3	0.2	0.3	0.05	0.05
Set 1	0.2	0.2	0.2	0.2	0.05	0.05
Set 2	0.3	0.3	0.3	0.3	0.05	0.05
Set 3	0.4	0.4	0.4	0.4	0.05	0.05
Set 4	0.5	0.5	0.5	0.5	0.05	0.05

Table 10. survey outputs section 12.25 in

Measured Depth	Inclination	Azimuth	Dog-Leg Severity
m	deg	deg	deg/30m
0	0	0	
21.6	0.111468658	111.7512414	0.154817581
31.6	0.118158771	291.7510326	0.688882288
41.6	0.090429788	111.7506191	0.625765676
51.6	0.067139649	291.7491725	0.47270831
61.6	0.022500404	291.7488866	0.133917734
71.6	0.032511793	291.7491753	0.030034166

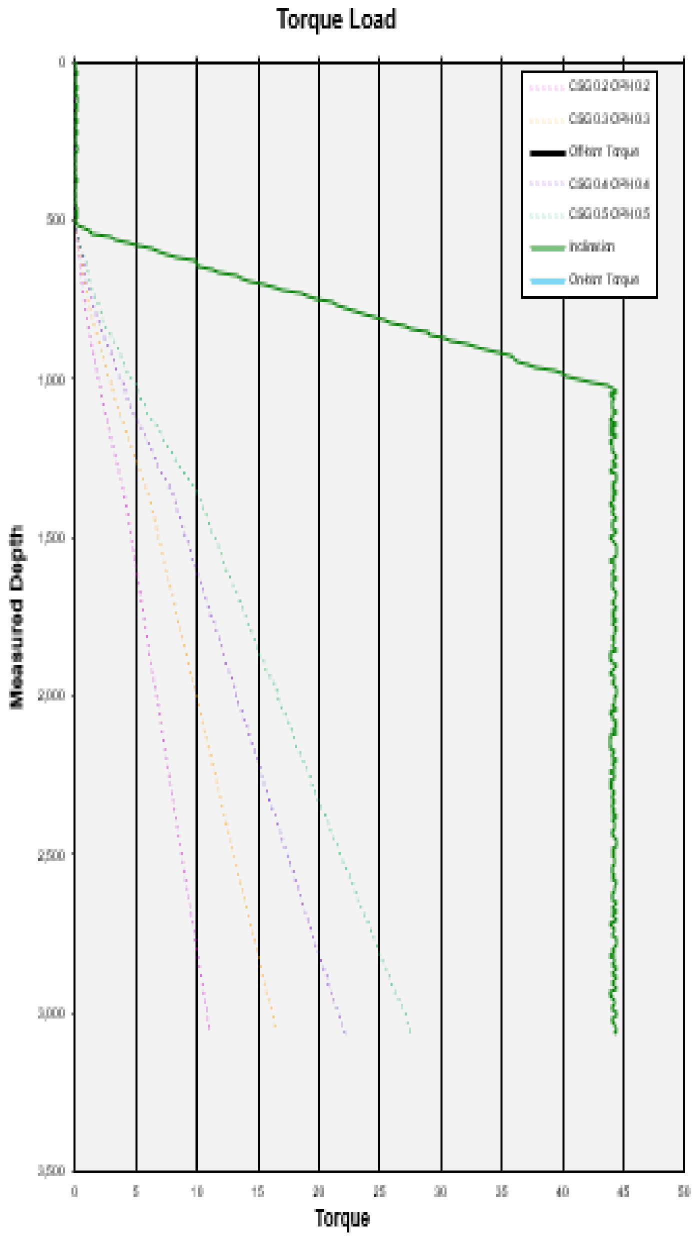


Figure 8. Torque plot

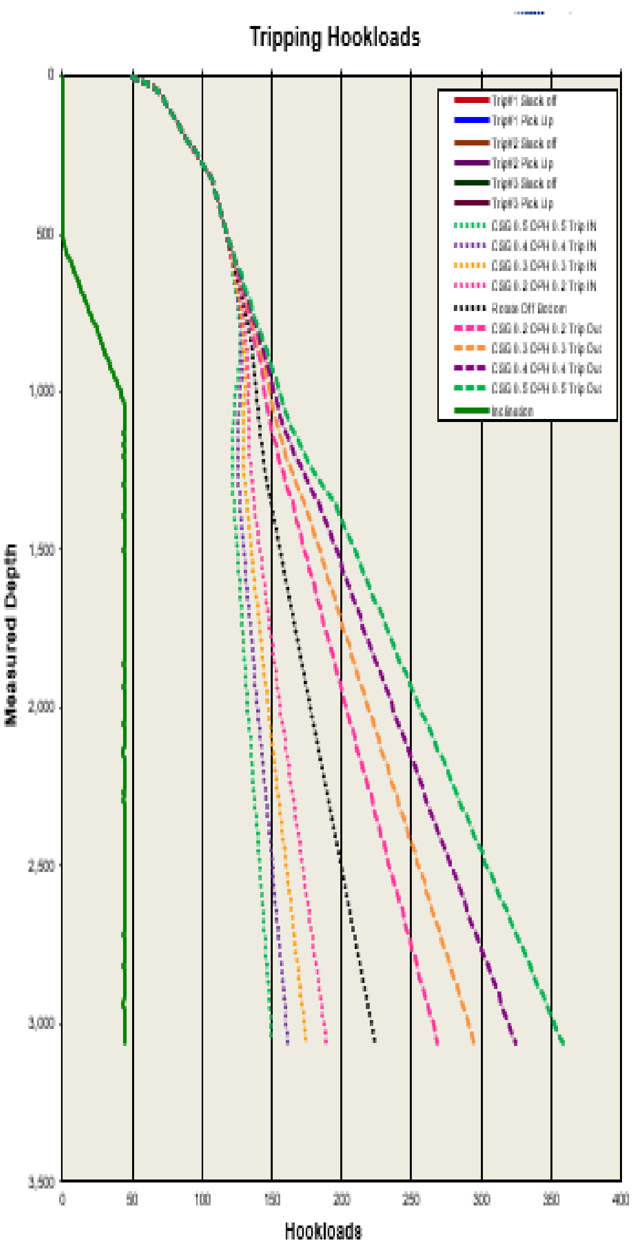


Figure 9. Tripping load plot

IV. Conclusion

The well was drilled vertically to a kickoff point of 520 meters. The inclination was built at 0º/30 m to 2.60º at 1710 m MD (1468.56 m TVD), The first section 26'' drilled from 30m MD to 480 m MD (480 m TVD) it was the vertical section with 9.3 ppg, then drill the second section by directional BHA from depth 480 m MD to 1725.68 m MD (1479.81m TVD) with 9.5ppg, then drill 12.25'' from 1725.68m MD to 3064.25 m MD (2439.77 m TVD) with MW 11.2ppg. The rotating weight of the drill string was 99,200 lbs. The friction coefficient was varied from 0.25 to 0.40. The minimum drag values are with a friction coefficient of 0.25. As the friction coefficient is increased, the drag trip out and trip in loads increase. However, the increase is not proportional; it is exponential. The increased drag in one section leads to increased tension (or compression) in the next section. Since the tension is higher, the normal force is higher and leads to a higher drag value, getting the pipe in the hole is more difficult at the higher friction coefficients.

Used water base mud its high friction factor than oil base mud. the water base mud for friction factor from 0.25 to 0.35 in casing and 0.25 to 0.40 in formation.

This study gives the significance and methodology of torque and drag calculations for the wells while drilling wells with directional well profile. Torque and drag are desired to be reduced and kept under control in directional well design and their drilling. While planning the directional wells a detailed torque and drag study is a necessity to be conducted prior to moving forward to execution. The benefit of this study is the ability to conduct accurate torque and drag calculations by means of defining the well trajectory and BHA specifications. The proposed methodology of the torque and drag calculation is great use to prevent the operational risks, down times, BHA item losses, and consequently delays for production.

The friction force analysis demonstrates the difference between rotating the string and not rotating the string. Rotation not only changes the direction of friction force; it also results in a change of axial tension that may change the total friction. Proper calibration is required to determine the effective friction coefficient.

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