Mohamed Sobhy I. Elsayed[1], Taher El-Fakharany[1], Osama I. Hassanein Hassan[2], Igor Martić[3], Nathalia Neves[4]*

CORRELATION BETWEEN PICKUP WEIGHT, SLACK-OFF WEIGHT, AND ROTATION STRING WEIGHT IN VERTICAL AND DIRECTIONAL WELLS

ZAVISNOST IZMEĐU TEŽINE PODIZANJA, TEŽINE ZAOSTAJANJA I TEŽINE ROTACIONE ŽICE U VERTIKALNIM I USMERENIM BUŠOTINAMA

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Adresa autora / Author's address:
1) Petroleum Department, Al-Azhar University, Faculty of Engineering, Cairo, Egypt
2) Electromechanical Engineering Technology Institute of Applied Technology, Abu Dhabi Polytechnic
3) University of Belgrade, Innovation Centre of the Faculty of Mechanical Engineering, Belgrade, Serbia
email: igor.martic@ymail.com
4) Global Corporate Solutions, Brazil

Keywords
- pickup weight (PUW)
- slack-off weight (SOW)
- rotation string weight (ROW)
- vertical well
- deviated well

Ključne reči
- težina podizanja (PUW)
- težina zaostajanja (SOW)
- težina rotacione žice (ROW)
- vertikalna bušotina
- odstupna bušotina

Abstract

Drilling activities in the oil and gas industry are capital-intensive and associated with high technology. With these assets, pickup weight, slack-off weight, and rotation string weight analyses are very important to ensure mechanical integrity of drillstring. Any form of interaction between the parties involved in drilling operation problems requires clear regulation regarding weight indicator relationships. This study attempts to make correlation between pickup weight, slack-off weight, and rotation string weight in vertical and directional wells in order to assess its applicability to other conditions. The search covers the key aspects of weight theory, provides a classification of weight in drilling operation, and discusses the correlation between three types of weight. It also considers the key principles of drag force, analyses of three types of weight in drilling operations by using the well data and highlights the shape of each well.

Izvod

Aktivnosti bušenja u industriji nafte i gasa su kapitalno intenzivne i povezane sa visokom tehnologijom. Parametri: težina podizanja, težina zaostajanja i analiza težine rotacione žice, su veoma važni da bi se obezbedio mehanički integritet bušeće kolone. Svaki oblik interakcije između strana uključenih u probleme operacija bušenja zahteva jasnu regulativu u pogledu odnosa indikatora težine. Ova studija pokušava da uspostavi vezu između težine podizanja, težine zaostajanja i težine rotacione žice u vertikalnim i usmerenim bušotinama kako bi se procenila njena primenljivost u drugim uslovima. Pretraga pokriva ključne aspekte teorije težine, daje klasifikaciju težine tokom operacije bušenja i razmatra vezu između tri tipa težine. Takođe se razmatraju ključni principi sile otpora, analiziraju se tri tipa težine u operacijama bušenja, korišćenjem baze podataka o bušotini i naglašava se oblik svake bušotine.

INTRODUCTION

As the cost of lifting oil is growing, it is important to increase the drilling efficiency and reduce well drilling time. A study of drilling wells shows that troubled stuck and drag accounts for 40% of rig time. In dollar terms, it is about 1 million USD per well /1/. Hence, earlier prediction in trouble stuck and drag and also increased drilling efficiency can result in tremendous time and cost savings.

This paper aims to study the correlation between pickup weight, slack-off weight, and rotation string weight in vertical and directional wells on drilling problem optimisation.

Efficiency and time usage is done by comparing the performance in 10 carefully selected Egypt wells.

The wells are analysed in terms of vertical and direction wells spent in each well. In addition, the pickup weight, slack-off weight, and rotation string weight are evaluated.

Research objectives are:

1. Identifying the factors of formation and change of the weight using the ten drilling wells in Egypt.
2. Analysing the pickup weight, slack-off weight, and rotation string weight in vertical and directional wells.
3. Correlation between pickup weight, slack-off weight, and rotation string weight in vertical and directional wells.
4. Defining the drilling problems from weight indication analysis.

Materials and methods:

1. Through pickup weight, slack-off weight, and rotation string weight in vertical and directional wells analysis, we study the relationship between them.
2. Through a ten wells collection data, we draw a figure for each well and try to make the correlation between them.
3. We study the factors that effect the drag force.
4. We design a new tool for drag reduction.

LITERATURE REVIEW

Technical limit is defined as the best possible well construction performance for a given set of design parameters. The technical limit approach is based on the time used to construct a theoretical well where all operations are carried out without any flaws and without any improvement potential. This is done by /2/:
– selecting a set of appropriate reference wells,
– dividing well construction process into sequences,
– quantifying the time used in each sequence or section.

The 'best in class' time usage in each section/operation of the reference wells is added up to generate the total time used to drill the theoretical well. As an analogue, the technical limit/theoretical well is kind of aiming to set the world record or at least regional record in all ten aspects of a decathlon. Removable time is defined as the difference between the actual well duration and technical limit time. Removable time is then divided into conventional lost or down time and invisible lost time. Invisible time being the classification of the activities that one would include in a normal well, like wiper trips, mid-section bit change or BHA trips, reaming, etc., /2/.

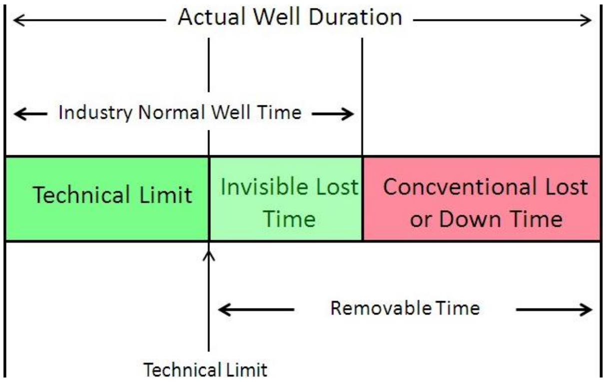

Figure 1. Schematic of the relationship between technical limit; invisible lost time; conventional lost or down time; actual well duration and industry normal well time.

Drag reduction method

To maximize possible target reach, it is important to apply all possible drag reduction techniques. This subchapter briefly summarizes drag reduction methods. In order to mitigate drag forces, engineers have developed various means. These methods may be listed as the following, /3/:
- well path design,
- lubricants,
- light-weight string components,
- hole cleaning,
- co-polymer beads,
- mechanical friction reduction tools,
- increased drill string and rig capability.

Drag is the function of the normal force, tubular movement and coefficient of friction. The drag value is also proportional to the normal force, coefficient of friction, drill string configuration radius and tubular movement. By reducing any of the mentioned components will lead to a reduction of drag value, /4/.

Efficient hole cleaning can eliminate problems with cutting accumulation and remediate high drag in the wells. In directional well, hole cleaning may be quite challenging and therefore must be carefully planned for each well section. Efficient cutting removal failure could lead to a significant torque and drag increase and without successful attempts to mitigate it, to even more severe operational problems such as drillstring stuck, /5/.

In order to decrease normal forces in a wellbore, the high buoyancy can be beneficial as it will limit the load on drill string. However, the disadvantage of a dense fluid is the fact that high particle size in the mud, low friction in the wellbore can also be obtained by using drilling mud additives, /6/.

By using mechanical devices and lubricants for a given well path and borehole condition, drag values could be significantly reduced. Different types of such mechanics can be installed between the connections or directly on the pipe. Most widely used in the industry are rollers and non-rotating sleeves. Presence of these components on the drillstring will assist drilling and running operations by increasing available weight and decreasing slip stick effect. The general recommendation during drilling directional well is to use low weight drill pipe and BHA. This will reduce tension and increase buoyancy, leading to low friction, /7/.

Drag optimisation elements

Drag optimisation process has 4 main focus points: drillstring integrity, drilling parameter, hole trajectory, and friction factor, /8/.

Drillstring integrity

Drill string integrity focuses on the prevention or reduction of mechanical overload, protection from fatigue and minimizing excessive shock and vibration. The most important issues are downhole vibrations like BHA buckling and torque and drag. Specialised computer software (*Drilling Simulator*) provides drag modelling.

Actual drillstring design run on (*Drilling Simulator*) allows to measure harmful force modes and identify active torque and drag mechanisms. Change of BHA drilling like (No. D/C, No. HWDP, RSS or MTR) enables corrective actions to be taken to reduce damage and to select the best design, /9/.

Drilling parameter

Drilling parameter focuses on keeping the hydrostatic and dynamic pressures between critical upper and lower operating limits, optimising circulating pressures, hole cleaning and clean-up cycles, optimising ROP and tripping speed without exceeding pressure limits. This is done by simulator models for drag to predict the effect of change drilling parameter WOB, RPM, and direction tool, on drag, /10/.

Based on change drilling parameter different results for drag and the best recommendations can be done.

Hole trajectory

In hole trajectory the drag optimisation process concerns about designing the best well pass.

Joint work on the simulator has discovered that the hole trajectory plays a fundamental role for optimising torque and drag in the planning stage, /11/.

Friction factor

Through joint work on simulator it is found that friction factor is very critical and also great factor effecting drag in all types of wells. The friction factor is an independent factor and depends only on contact force between drill string and well bore. Based on simulator results, the decision is taking matter on reducing the friction factor by reducing contact area between drill string and well bore, /12/.

The following section describes parameters and targets that have been used in the performance development study.

Parameters

SOW – Slack-off Weight is measured in (Kip) and is the weight of string when RIH without rotation.

PUW – Pick-up Weight is measured in (Kip) and is the weight of string when POOH without rotation.

ROT.W - Rotation Weight is measured in (Kip) and is the weight of string when POOH with rotation (off BTM).

DRILL.W - Drilling Weight is measured in (Kip) and is the weight of string when RIH with rotation (on BTM).

METHODOLOGY

Source of information

Well study has covered all Egyptian fields and involves different drilling facilities, permanent as well as mobile. The End of Well Reports made by the Directional Drilling, Measurements while drilling, Surface data logging and Advanced Drilling Technology service lines and the operator company's drilling programme are used as the source of information in the study. Eight wells are selected and considered appropriate for comparison. These wells are referred to as well #1-10 in further discussion. Data for five vertical wells is given in Table 1 and in Figs. 2-6, while 5 direction well data is presented in Table 2 and in Figs. 7-11. Finally, Table 3 presents results of the market survey for Torque & Drag Optimisation down hole tool limitation.

Planning

Includes collecting pick-up weight, slack-off weight, and rotation string weight data for 10 wells in two categories vertical and directional well, and drawing the relationship between pick-up weight, slack-off weight, rotation string weight, and measured depth.

Table 1. Value of rotation STRG weight, pick-up weight, and slack-off weight for 5 vertical wells.

No. of well	Depth (m) (ft)	Rotating STRG weight (kg) (Klbf)	Pick-up weight (kg) (Klbf)	Slack-off weight (kg) (Klbf)
Well No.1	291.08 (955.00)	160.94 (73.00)	165.35 (75.00)	143.30 (65.00)
	509.02 (1,670.00)	171.96 (78.00)	176.37 (80.00)	165.35 (75.00)
	740.66 (2,430.00)	194.00 (88.00)	198.42 (90.00)	187.39 (85.00)
	835.15 (2,740.00)	176.37 (80.00)	187.39 (85.00)	165.35 (75.00)
	1091.18 (3,580.00)	227.07 (103.00)	231.48 (105.00)	220.46 (100.00)
	1400.56 (4,595.00)	242.51 (110.00)	253.53 (115.00)	227.07 (103.00)
Well No.2	204.22 (670.00)	99.21 (45.00)	110.23 (50.00)	88.18 (40.00)
	524.26 (1,720.00)	158.73 (72.00)	165.35 (75.00)	154.32 (70.00)
	737.62 (2,420.00)	194.00 (88.00)	198.42 (90.00)	187.39 (85.00)
	946.40 (3,105.00)	198.42 (90.00)	209.44 (95.00)	176.37 (80.00)
	1158.24 (3,800.00)	213.85 (97.00)	220.46 (100.00)	209.44 (95.00)
	1376.17 (4,515.00)	235.89 (107.00)	249.12 (113.00)	231.48 (105.00)
Well No.3	518.16 (1,700.00)	286.60 (130.00)	297.62 (135.00)	275.58 (125.00)
	606.55 (1,990.00)	330.69 (150.00)	330.69 (150.00)	319.67 (145.00)
	1463.04 (4,800.00)	410.06 (186.00)	418.87 (190.00)	403.44 (183.00)
	1524.00 (5,000.00)	418.87 (190.00)	440.92 (200.00)	407.85 (185.00)
	1828.80 (6,000.00)	440.92 (200.00)	462.97 (210.00)	429.90 (195.00)
	1981.20 (6,500.00)	451.95 (205.00)	485.02 (220.00)	440.92 (200.00)
Well No.4	899.16 (2,950.00)	282.19 (128.00)	286.60 (130.00)	275.58 (125.00)
	1143.00 (3,750.00)	315.26 (143.00)	324.08 (147.00)	308.65 (140.00)
	1524.00 (5,000.00)	341.72 (155.00)	352.74 (160.00)	337.30 (153.00)
	1828.80 (6,000.00)	352.74 (160.00)	374.78 (170.00)	341.72 (155.00)
	2133.60 (7,000.00)	385.81 (175.00)	396.83 (180.00)	352.74 (160.00)
	2438.40 (8,000.00)	418.87 (190.00)	440.92 (200.00)	396.83 (180.00)
Well No.5	518.16 (1,700.00)	275.58 (125.00)	286.60 (130.00)	264.55 (120.00)
	609.60 (2,000.00)	297.62 (135.00)	308.65 (140.00)	286.60 (130.00)
	822.96 (2,700.00)	319.67 (145.00)	330.69 (150.00)	308.65 (140.00)
	1889.76 (6,200.00)	385.81 (175.00)	396.83 (180.00)	374.78 (170.00)
	2743.20 (9,000.00)	540.13 (245.00)	551.15 (250.00)	529.10 (240.00)
	2962.66 (9,720.00)	562.18 (255.00)	573.20 (260.00)	551.15 (250.00)
	3108.96(10,200.00)	540.13 (245.00)	551.15 (250.00)	529.10 (240.00)
	3657.60(12,000.00)	595.25 (270.00)	606.27 (275.00)	584.22 (265.00)
	4495.80(14,750.00)	705.48 (320.00)	716.50 (325.00)	694.45 (315.00)

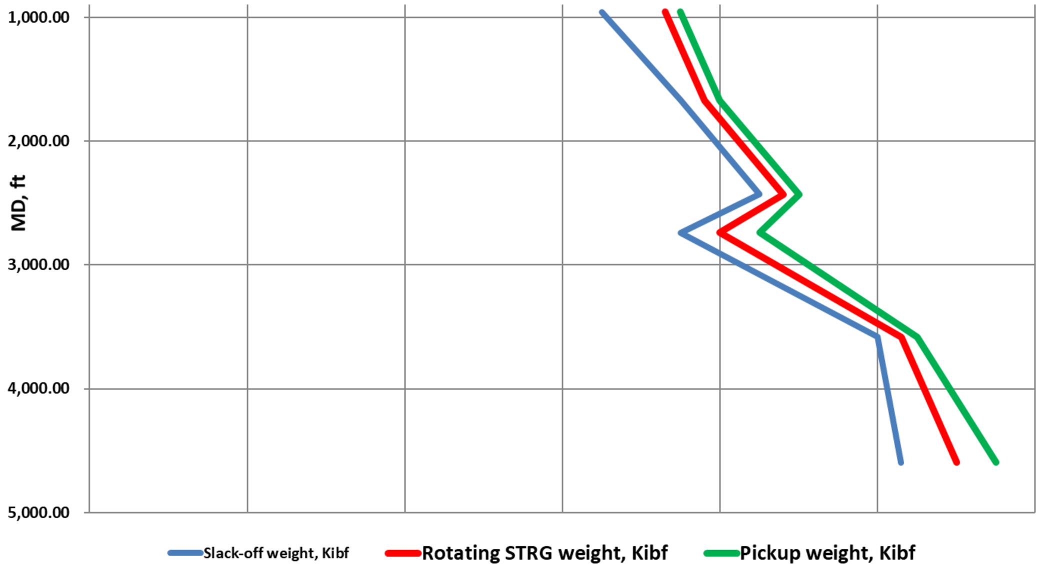

Figure 2. Rotation STRG weight, pick-up weight, slack-off weight vs. measured depth for vertical well No.1.

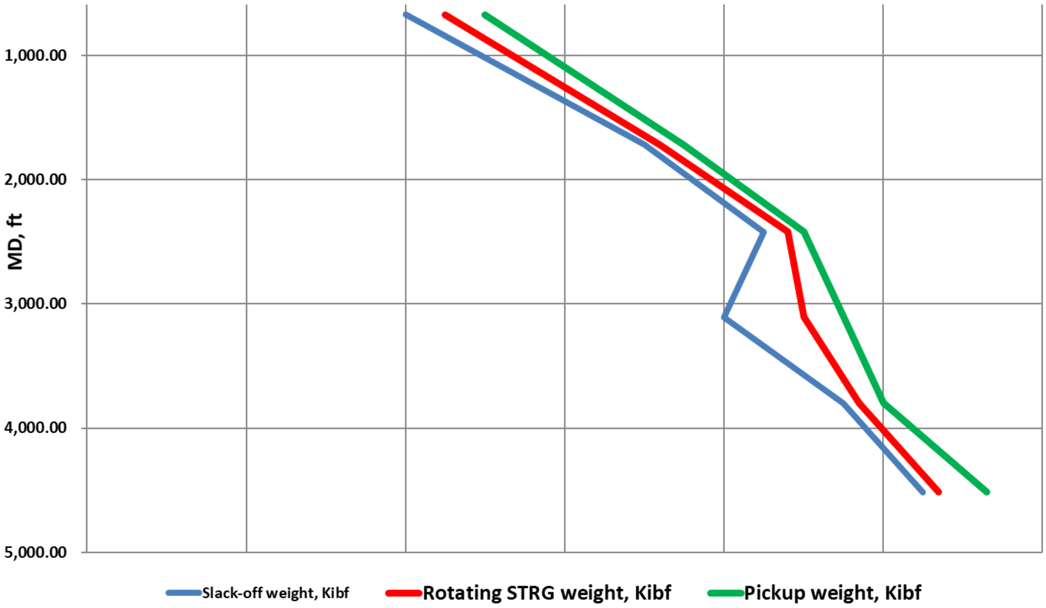

Figure 3. Rotation STRG weight, pick-up weight, slack-off weight vs. measured depth for vertical well No.2.

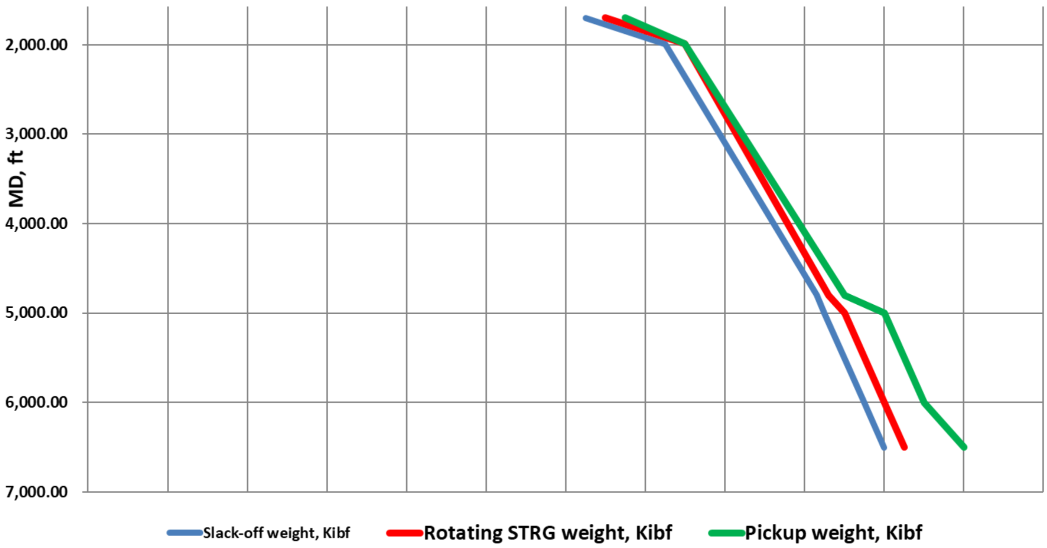

Figure 4. Rotation STRG weight, pick-up weight, slack-off weight vs. measured depth for vertical well No.3.

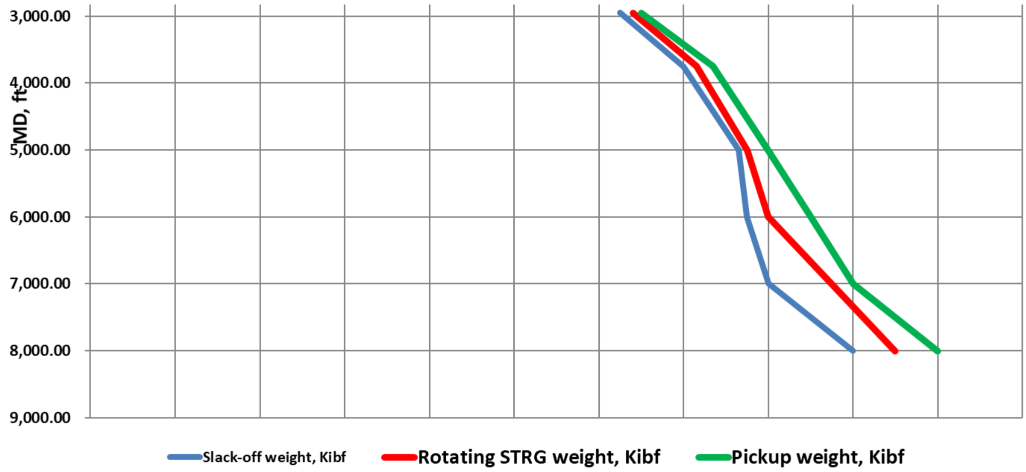

Figure 5. Rotation STRG weight, pick-up weight, slack-off weight vs. measured depth for vertical well No.4.

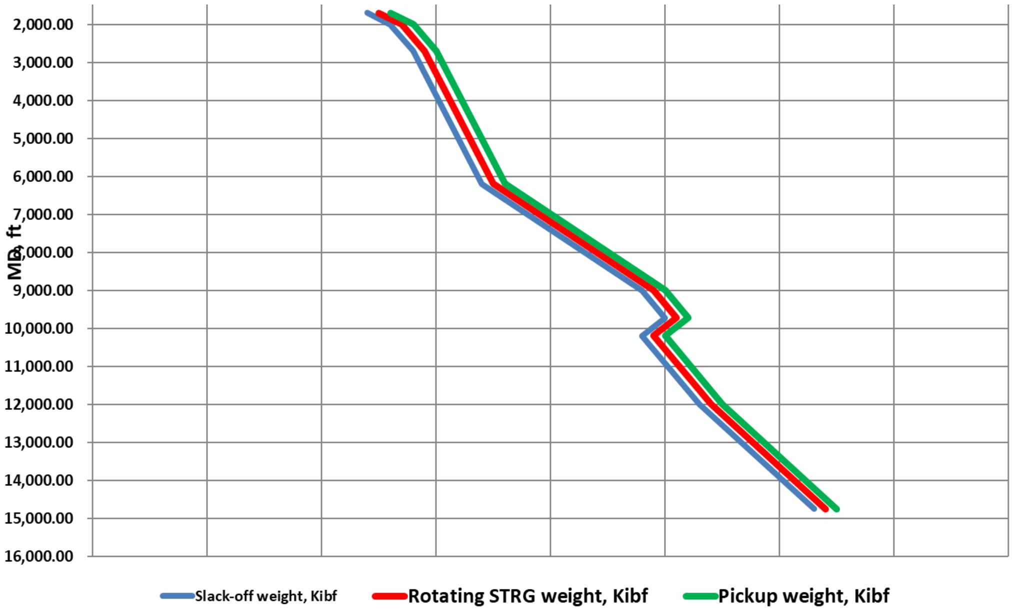

Figure 6. Rotation STRG weight, pick-up weight, slack-off weight vs. measured depth for vertical well No.5.

Table 2. Rotation STRG weight, pick-up weight, and slack-off weight for 5 direction wells.

No. of well	Depth (m) (ft)	Rotating STRG weight (kg) (Klbf)	Pick-up weight (kg) (Klbf)	Slack-off weight (kg) (Klbf)
Well No.1	152.40 (500.00)	231.48 (105.00)	242.51 (110.00)	220.46 (100.00)
	304.80 (1,000.00)	253.53 (115.00)	264.55 (120.00)	242.51 (110.00)
	457.20 (1,500.00)	275.58 (125.00)	286.60 (130.00)	264.55 (120.00)
	1524.00 (5,000.00)	529.10 (240.00)	661.39 (300.00)	440.92 (200.00)
	2438.40 (8,000.00)	639.34 (290.00)	859.80 (390.00)	507.06 (230.00)
	2743.20 (9,000.00)	656.98 (298.00)	881.85 (400.00)	507.06 (230.00)
Well No.2	243.84 (800.00)	220.46 (100)	231.48 (105.00)	213.85 (97.00)
	426.72 (1,400.00)	220.46 (100)	231.48 (105.00)	213.85 (97.00)
	726.00 (2,500.00)	233.69 (106.00)	297.62 (135.00)	213.85 (97.00)
	1066.80 (3,500.00)	264.55 (120.00)	330.69 (150.00)	242.51 (110.00)
	1676.40 (5,500.00)	319.67 (145.00)	462.97 (210.00)	275.58 (125.00)
	2286.00 (7,500.00)	352.74 (160.00)	595.25 (270.00)	286.60 (130.00)
Well No.3	335.28 (1,100.00)	308.65 (140.00)	308.65 (140.00)	308.65 (140.00)
	731.52 (2,400.00)	341.72 (155.00)	352.74 (160.00)	330.69 (150.00)
	822.96 (2,700.00)	352.74 (160.00)	363.76 (165.00)	341.72 (155.00)
	1097.28 (3,600.00)	385.81 (175.00)	396.83 (180.00)	374.78 (170.00)
	1584.96 (5,200.00)	407.85 (185.00)	429.90 (195.00)	385.81 (175.00)
	2926.08 (9,600.00)	495.36 (225.00)	617.29 (280.00)	551.15 (250.00)
	3810.00(12,500.00)	617.29 (280.00)	661.39 (300.00)	650.36 (295.00)
	4145.28(13,600.00)	595.25 (270.00)	639.34 (290.00)	617.29 (280.00)
	4419.60(14,500.00)	727.52 (330.00)	749.57 (340.00)	683.43 (310.00)
Well No.4	243.84 (800.00)	286.60 (130.00)	297.62 (135.00)	275.58 (125.00)
	426.72 (1,400.00)	308.65 (140.00)	319.67 (145.00)	297.62 (135.00)

	548.64 (1,800.00)	330.69 (150.00)	341.72 (155.00)	319.67 (145.00)
	1219.20 (4,000.00)	341.72 (155.00)	352.74 (160.00)	330.69 (150.00)
	1524.00 (5,000.00)	352.74 (160.00)	363.76 (165.00)	341.72 (155.00)
	2438.40 (8,000.00)	429.90 (195.00)	440.92 (200.00)	418.87 (190.00)
	2743.20 (9,000.00)	451.95 (205.00)	462.97 (210.00)	440.92 (200.00)
	2987.04 (9,800.00)	473.99 (215.00)	485.02 (220.00)	462.97 (210.00)
	3169.92(10,400.00)	496.04 (225.00)	507.06 (230.00)	485.02 (220.00)
Well No.5	92.05 (302.00)	205.03 (93.00)	205.03 (93.00)	205.03 (93.00)
	182.88 (600.00)	242.51 (110.00)	242.51 (110.00)	242.51 (110.00)
	213.36 (700.00)	242.51 (110.00)	242.51 (110.00)	242.51 (110.00)
	1758.69 (5,770.00)	436.51 (198.00)	562.18 (255.00)	396.83 (180.00)
	1900.43 (6,235.00)	429.90 (195.00)	495.36 (225.00)	385.81 (175.00)
	2106.17 (6,910.00)	462.97 (210.00)	518.08 (235.00)	418.87 (190.00)
	2438.40 (8,000.00)	451.95 (205.00)	540.13 (245.00)	385.81 (175.00)
	2590.80 (8,500.00)	462.97 (210.00)	551.15 (250.00)	407.85 (185.00)
	2743.20 (9,000.00)	473.99 (215.00)	573.20 (260.00)	429.90 (195.00)

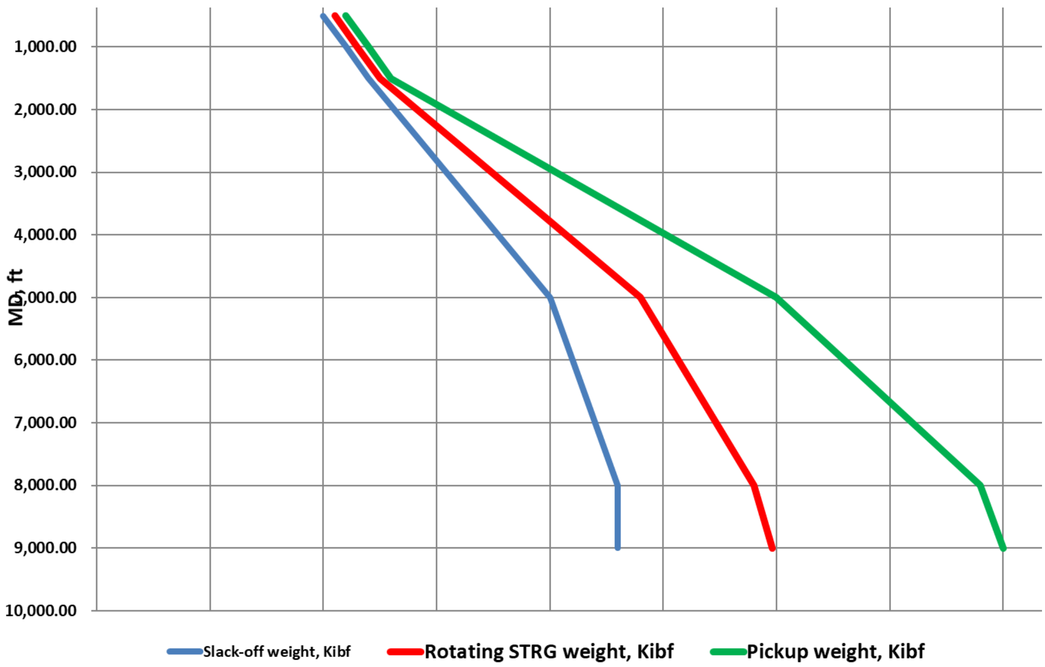

Figure 7. Rotation STRG weight, pick-up weight, slack-off weight vs. measured depth for direction well No.1.

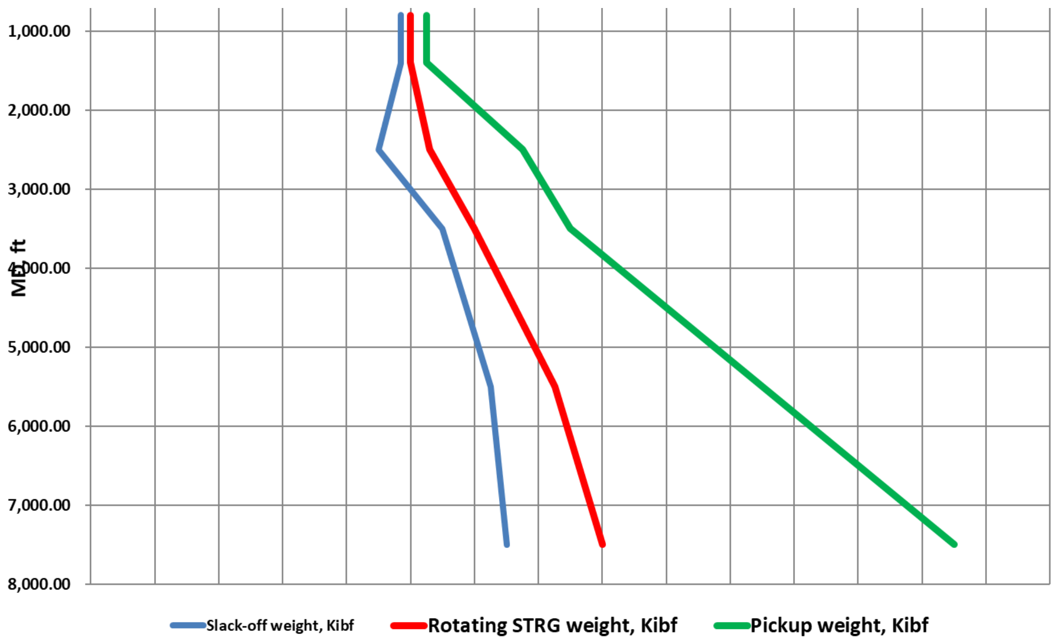

Figure 8. Rotation STRG weight, pick-up weight, slack-off weight vs. measured depth for direction well No.2.

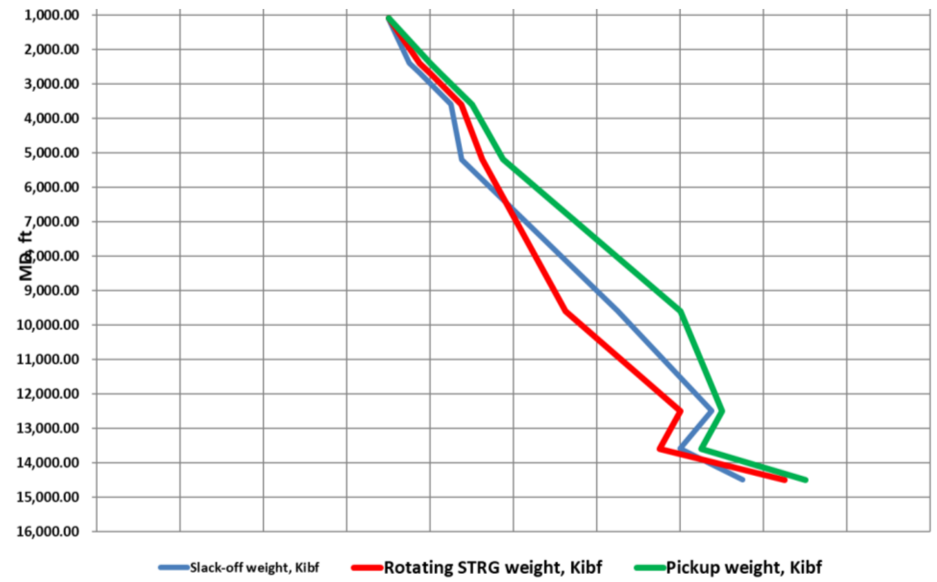

Figure 9. Rotation STRG weight, pick-up weight, slack-off weight vs. measured depth for direction well No.3.

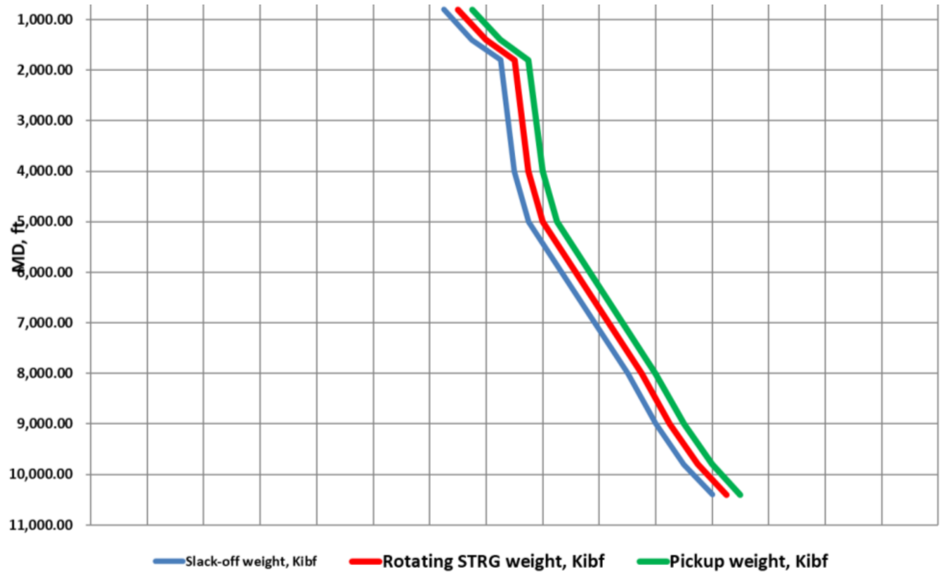

Figure 10. Rotation STRG weight, pick-up weight, slack-off weight vs. measured depth for direction well No.4.

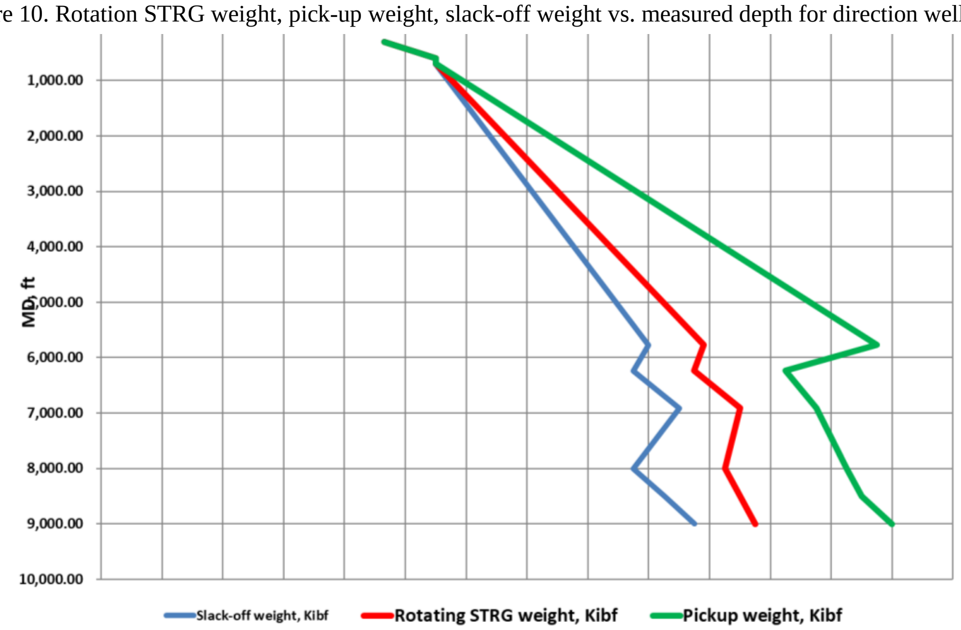

Figure 11. Rotation STRG weight, pick-up weight, slack-off weight vs. measured depth for direction well No.5.

Table 3. Market survey for torque and drag optimisation down hole tool limitation.

Market survey for Torque & Drag Optimization down hole tool limitation						
Contractor name	Torque reduction %	Mechanism	Blade type	Hole type	Side force resistance (kg) (Ibf)	Remarks
Paradigm Drilling Services	25 – 40	bearing with mandrel	rubber	cased hole mainly	4535.92 (10 000)	limited
Frank's International (DSTR)	30 – 40	bearing with mandrel	alloy	cased & open	6350.29 (14 000)	limited
Halliburton	25 – 40	bearing with mandrel	alloy	cased & open	6803.88 (15 000)	limited
Non-rotating drill pipe protector	15 – 25	centralizer	rubber & alloy	cased hole	2267.96 (5 000)	limited
New torque and drag reduction tools	70 – 90	free rotation	alloy	cased & open	22679.62 (50 000)	*easy To Use *less maintenance *higher efficiency *high operation durability *less capital cost *work on T & D *have multiple function & advantages

RESULTS

This chapter presents the results from the performance study of selected wells. The analysis has been carried out on each variable.

Vertical well

Though joint pickup weight, slack-off weight and rotation string vs. measured depth indicates that all type of weight increases with depth. There is slight difference between values meaning a slight drag, the lowest value of slack of weight followed by rotation string weight and the highest value is pick-up.

Direction well

Though joint pickup weight, slack-off weight and rotation string vs. measured depth indicates that all type of weight increase with depth. There is a large difference between values meaning a high drag, the lowest value of slack of weight followed by rotation string weight, and the highest value is pick-up, whereas in well No.3 there is conflict between slack of weight and rotation string weight.

CONCLUSION

Drag optimisation is studied by using end-of-well-reports from 10 wells of different type region in Egypt. The studied wells cover all type of well vertical and direction containing performance incentives. Value of pickup weight, slack-off weight, and rotation string weight, depend on hole inclination angle mainly, hole cleaning condition, and type of formation. In well No.3 the inclination angle was up to 65° and hole cleaning was very bad.

Advantages of the new torque and drag reduction tools (prototype available):

- control directional behaviour,
- concentrated BHA weight on the drill bit,
- minimized bending and vibration damage,
- reduced torque and drag by limiting wall contact,
- helps prevent differential sticking and key seating,
- smooth hole geometry,

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