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NPT STATISTICAL ANALYSIS AND BENCHMARKING FOR HPHT WELLS

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Abstract- High pressure, high temperature (HPHT) wells have widely appeared and increased all over the world. Most of these well have a lot of problems during drilling operations, which lead to lose money and waste time. This time is called non-productive time (NPT). The HPHT wells become a challenge to any drilling engineer or designer due to their problems. Therefore, this paper aims to review and analyze most of the drilling problems coming from HPHT wells. Furthermore, NPT statistical study is done to differentiate between the various causes of HPHT wells' problems. A benchmarking study is also done so as to determine the drilling performance relative to the best well. A comparison is performed to know the well performance locally and globally.

Keywords – Benchmarking, best well, drilling problems, performance,

I. INTRODUCTION

Well planners and operations engineers are frequently called upon to assess the cost and performance of their drilling and well-services activities. These evaluations may be used to identify areas for improvement, as well as operators or activities that are doing well or poorly, or to compare the performance of different operators or contractors. Analyses may also be used to compare and assess the efficacy of various well-construction processes and technologies. The operator can do these sorts of analysis using electronic data captured at the rig site and connected into corporate reporting systems or data storage. "Performance Benchmarking" refers to everything mentioned above. As a result, performance analysis is quite beneficial when it comes to determining drilling performance. A well-operations database's primary purpose is to allow for the analysis of recorded data in order to optimize future wellbore operations. As a result, the engineer is able to treat the data as a valuable asset. This also allows operator engineers to run any type of structured query for a range of studies, performance benchmarking, research, or statistical data collection for corporate or government reporting [1, 2]. Although there are several textbooks and scientific articles have been studied almost all drilling branches, there are only few that have been presented our topic. Benchmarking definition, terms, performance qualifiers, efficiency and value, and drilling performance were discussed by Mensa-Wilmot, et al. [3]. Additionally, Zafar and Akinniranye [4] provided a systematic way to measuring drilling success by defining key performance indicators (KPIs), which necessitated specialized expertise and a major financial investment that is generally justified only on the larger projects. KPIs are created and statistically assessed for core trends and convergence, resulting in benchmarks. The KPIs, together with their associated probabilities, may be utilized to create risk-based spending authorizations (AFEs). Eren and Kok [5] published a new benchmarking tool for drilling performance in the rate of penetration (ROP) indexing approach was modeled and used to test the drillability of 40 wells drilled in Middle East Geomarket. Furthermore, Valdez and Sager [6] reached to continuous improvement and benchmarking approaches might be used to monitor, document, evaluate, and discover best practices during the drilling process, which can greatly enhance operational efficiency and lower well costs. They concluded that Benchmarking is a time-consuming procedure that needs a lot of preparation, measurement, comparison, and analysis. However, putting the lessons learnt into practice and making process improvements as a consequence of the process can have a long-term positive impact. Therefore, the aim of this study is to use benchmarking data and study methodology, along with NPT historical data, to review analyze annual drilling performance for HPHT wells.

Determining the validity of the methodology and game types for HPHT wells, making recommendations if revisions are considered appropriate

- Inform multi-year performance trends for D/10k and NPT, as well as "Best Operator" or "Best in region" for HPHT well
- Complete analysis of BW intelligence / competition to identify any opportunities for improvement that can be incorporated into well plans
- Keep track of performance expectations for wells and annual plans

Some of the expected lines of investigation are:

- Performance trends and determinants from year to year
- Analysis for HPHT well (D/10k vs. platform type, mud type, directional profile, tubing strings, etc.)
- NPT trends in relation to the type of game, the type of platform, the type of mud, the directional profile, etc.

II. **A BENCHMARKING COMPARISON OF HPHT WELLS**

The drilling and completion D&C department completes regularly an annual drilling benchmarking to understand the position of HPHT wells against the key performance indicator (KPI) of days / 10,000 ft of drilled hole (D/10k). This data is collected from several sources and then aggregated into a central database for last year's and multi-year performance analysis, both globally and regionally. Benchmarking is done by grouping comparable types of wells around the world and identifying the 5th percentile of performance for that well type (eg, land, development wells, 4-column). That performance threshold is then designated "Best Well" (BW) for the type of game, and all wells in that type of game are compared to BW to determine performance against it.

Mathematical formula for: (D/10k real - BW D/10k) / D real/10k = Difference from BW. This Gap from BW is simply the percentage of time that the well in question took, above the BW reference level , for drilling the well. Therefore, a 50% difference from BW would indicate that the well lasted twice as long as the reference value. Gaps may not be> 100%, but may be <0 if the well in question exceeded the benchmark. A separate annual study of the global downtime (NPT) trends of HPHT probes is also completed (but has no competitive benchmarks). NPT refers to any time spent on a well that is not directly in service of the well's objectives (eg, blocked pipe, platform repairs, return losses, etc.). This study uses data captured in the wells to inform historical NPT trends and factors that may allow for performance / technology interventions. At present, there is no direct link between these two studies or methodologies. Based on the above formula, eight HPHT wells were taken from the Middle East to our study. Table 1 shows a comparison between those wells based on drilled days, rig NPT and total NPT. Well 6 is the best well based on the total NPT (Figure 1), however well 5 represents the least number of drilled days (Figure 2). A comparison between those wells based on time-depth curve is shown in Figure 3. Further, another comparison is shown in Figure 4 that illustrates the benchmarking globally and locally.

Table 1. Statistical analysis of HPHT wells

Well	Days/10K	Total NPT%	Rig NPT%
1	66.6	29.9	2.8
2	65.1	42	27.5
3	103	53	23.7
4	135.1	45.1	5.1
5	62.7	25.2	7.4
6	78.3	16.2	2.6
7	131	32	8.2
8	86	49	14

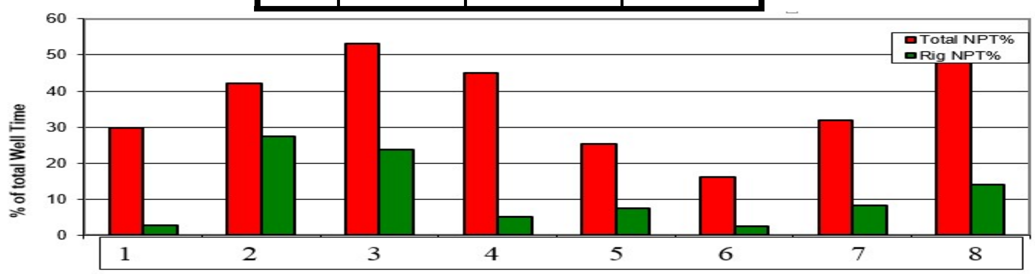

Figure 1. Non-productive time of HPHT wells.

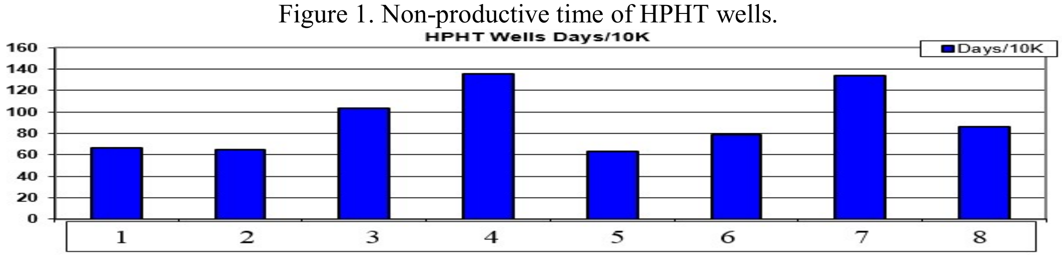

Figure 2. Benchmarking of HPHT wells.

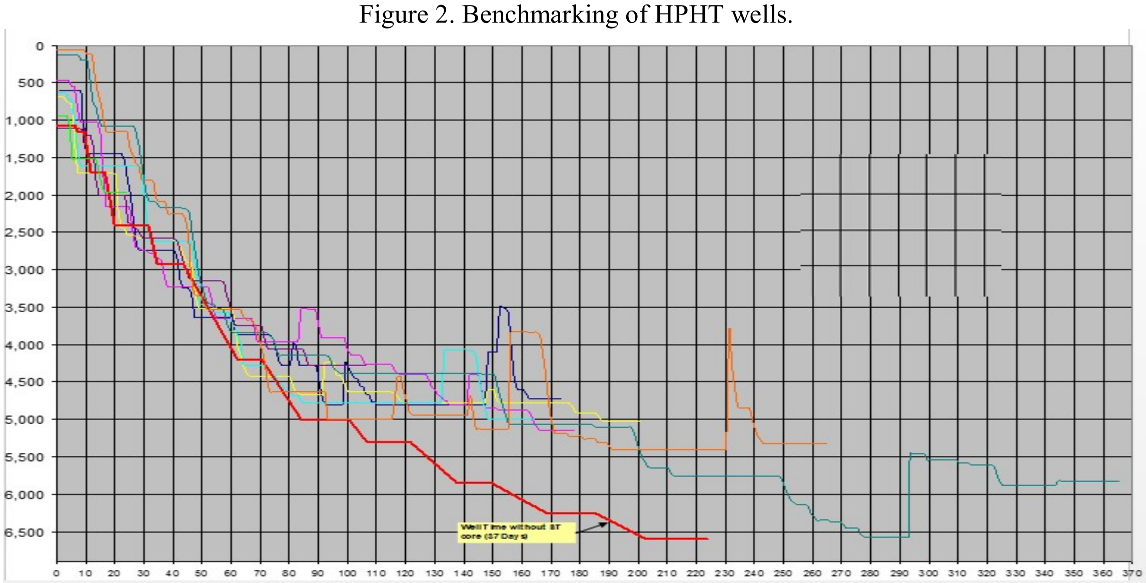

Figure 3. Time- depth curve comparison.

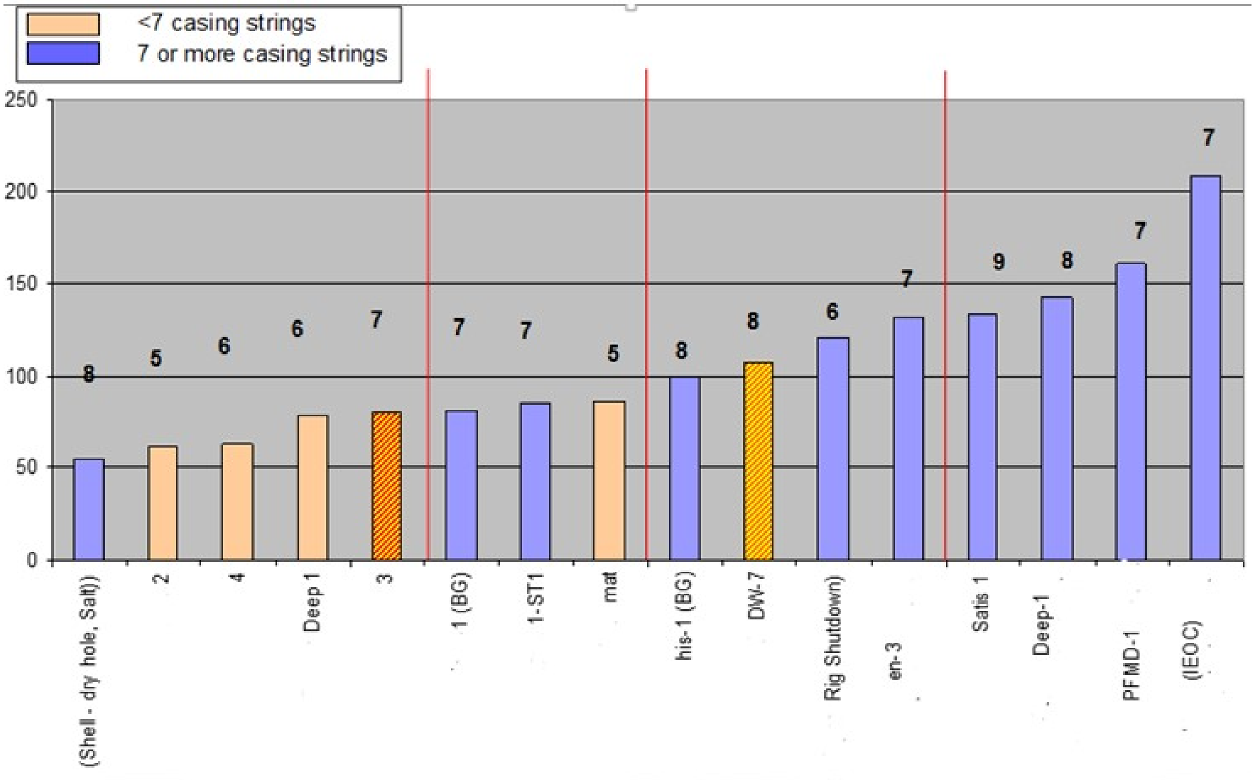

Figure 4. Benchmarking with HPHT well locally and globally.

III. NPT ANALYSIS OF HPHT WELLS' OPERATIONS

A. HPHT Wells Data

HPHT exploration and evaluation wells were first successfully found during the penetration of the Oligocene into the North Africa (Discovery 2008). It was remarkable that Rig Repair NPT high for a long duration of the contract, later it was necessary to start the improvement. BOP control issues caused two significant cons and NPT - later remedied by a complete HW / SW troubleshooting effort. The significant period of non-functioning of the cementation led to a renewed focus on the design and execution of cement works. As a whole, continuous NPT and Days / 10K continuous improvements were required for each probe. The 15,000 jackup valued at 400 ft of water has been used for a 3-year contract since April 2007, with an installation rate of $ 210,000 / day and an all-inclusive spread rate of ~ $ 650,000 / day to drill all these wells. All the data are collected and analyzed in order to study the NPT main causes and reasons. Figures 5 through 8 and Table 2 show the results of the study.

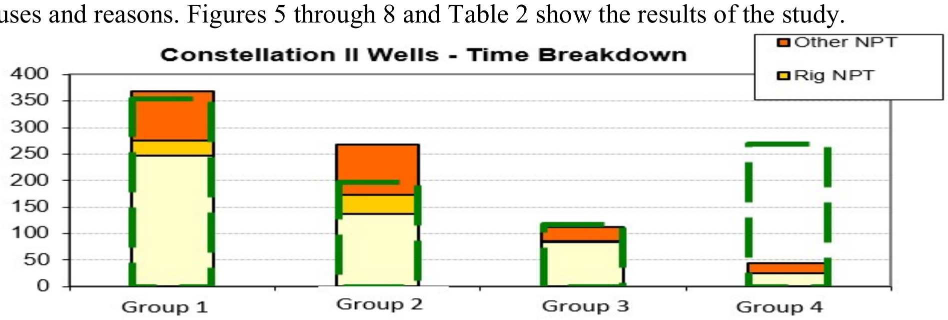

Figure 5. NPT analysis and Benchmarching for Constellation II wells.

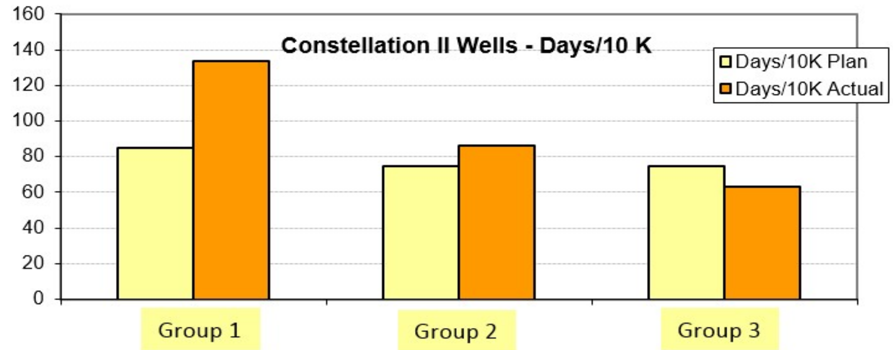

Figure 6. Benchmarching of the first 3 groups between the actual and real drilled days.

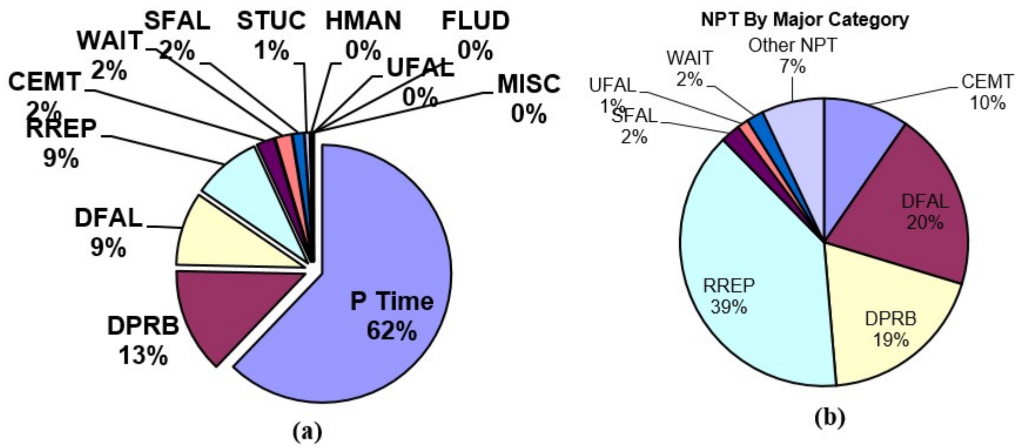

Figura 7. (a) NPT time distribution of HPHT wells (b) NPT on major categories.

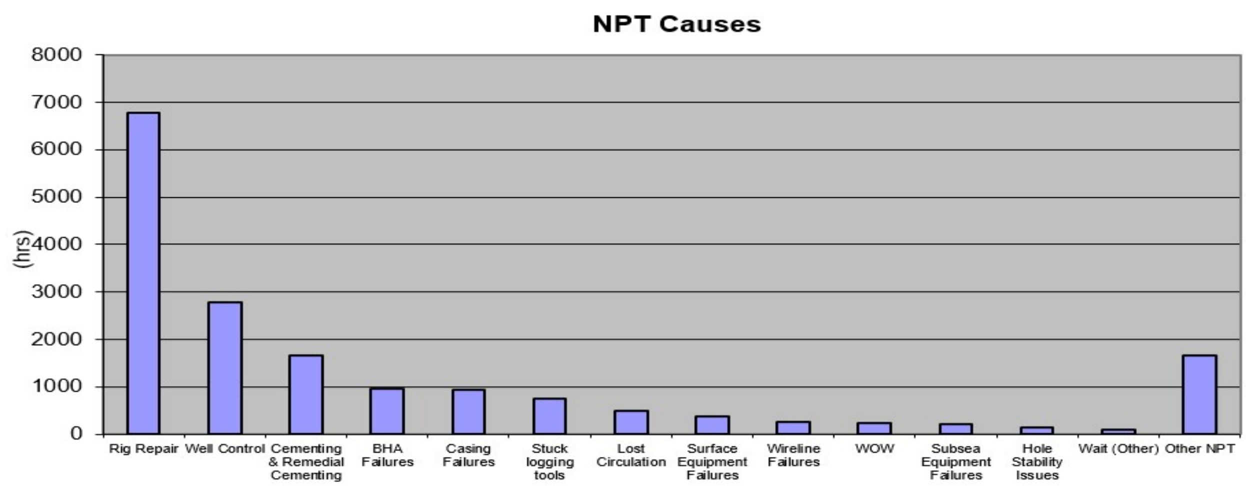

Figure 8. Bar chart for major causes of NPT.

As a general summary, the total duration of HPHT operations is about 5 years for 8 wells so far. In addition, the total NPT is 17404 hours, almost 2 years, at 40% of the total time of operations. The three most important causes of

NPT are repair of the platform, malfunctions in the bottom and problems in the bottom. The average NPT per well is 38.5%.

Table 2. Summary of HPHT wells' operations

	Operations Time	NPT	NPT %
Hrs	42971.83	17404.25	**40.50%**
Days	1790.49	725.18	
Years	4.91	1.99	

III. RESULTS AND DISCUSSIONS

A. Main collaborators (Figure 5 through 8)

The main absolute contributor to NPT of HTHP wells is Rig Repair, followed by Well Control events. In terms of services, the top three sectors contributing to NPT (excluding drilling contractors) are cementing, BHA component suppliers (mainly DD & MWD/LWD) and Wireline Logging. From the perspective of the borehole problem, well control is the most important issue. The stability of the hole is not a major issue, as most of these wells were vertical, with short side angles with a small angle for evaluation purposes. There are no major geotechnical stability issues in the collected data, and the selected fluid systems have been successful for these wells (Figures 5 and 6).

Platform repairs (6782 hours - 282.5 days): Various problems with the PNA and Constellation II platforms, both drilled 7 of the 8 wells.

PNA: BOP and Crane issues on group 2, which shut down the platform for 110 days. Again, BOP and Crane are having trouble shutting down the platform for 48 days on Deep wells. Constellation 2: A month of NPT on Satis 1 due to various platform repair issues, the biggest of which is the failure of the BOP Control system (failure of the software locked system - 13 days) and the failure of the Traveling Block Dolley frame (3 days). Another month on well MAT, due to the failure of the control system, which opened the pipes, which caused the suspended line to fall into the well, which led to the loss of the hole and BHA and the diversion of the well.

The problems with both platforms can be attributed to the fact that their contracts started after a long period of reduced tariffs, leading contractors to minimize maintenance costs and spare parts stocks without the intervention of former operators. Most of the minor downtime of the installation can be explained by the fact that the nature of these wells means that the components of the installation are operated at loads that are very close to their limits. It is noteworthy that the problems on the NAP have been significantly reduced due to the additional focus on the contractor system and the addition of a "Well Maintenance" time, which is amortized by reducing the NPT (the last well on the NAP had only 66 hours, equivalent to 2.6% of the total well time, attributed to the repair of the platform). Much of the time to repair the platform on Constellation II was due to the BOP control system being too complex. The system was completely repaired after the missing string event and all software and hardware defects were fixed.

Well control (2775 hours - 116 days): All wells so far have had one or more control situations, except well 2. The wells that hit are well 1 - 3 kicks, Deep1 – 2 kicks, well 3 – 3kicks, Satis 1 - 1 kick, well 4 - 1 kick, Deep2 - 2 kicks, MAT - 1 kicks. 83% of the downtime for Well Control took place on the 5 deep wells. Due to the narrow PP / FG margin, most well control events resulted in BHA soldering, loss of the hole section, and subsequent diversion of the well. 17% of the downtime for the well control took place on the 2 Jackup wells, where the combination of higher PP / FG margins and the managed pressure drilling system (MPD) allowed a better recovery of the well control events. MPD allows the pipe to rotate while closed to prevent sticking.

Cementation problems (1671 hours - 69 days) - (includes remedial cementation): 13 5/8 ”column on Satis 1 (27 days). The volume of the slurry was less than the uncertainty of movement, and all the cement was left inside the housing when the non-shearing lower stopper was mistaken for hitting the upper stopper. As he drilled the cement, the column parted. He squeezed the stump and the "new sheep" and continued operations. Root Cause was a poorly designed cement work. Poorly designed cement work, again in Satis, when the 11 ¾ inch Liner cement was prematurely fixed inside the housing causing 13 days of shutdown. Other cementing problems are more related to the drilling conditions, as opposed to the poor design of the work, the main factor being the remedial cementing operations (tightening of shoes) in accordance with the models of housing with tight tolerance and narrow slopes PP / FG and the resulting losses. Invisible lost time (and additional stress) related to cement units and / or delivery systems - unit computers malfunction, LAS units malfunction requiring manual chemical addition, and platform delivery systems fail to power the units sufficiently.

BHA failures (972 hours - 40.5 days): Mechanical failures: mainly due to vibration, especially to bore under bore during BHA drilling. Main events: BHA Twistoff on well 1 event (5.4 days). BHA twisted under a Rhinoreamer in the 16.5 "x 20" section. BHA failure on Deep 1 & 2: pressure loss, POOH to be investigated, bit and reamer damage (2 days) MWD/LWD tool failures: 553 hours lost on trips to replace failed tools. Decision trees are always in place to define when BHA needs to be triggered and when drilling can be continued. The exploratory / evaluative nature of these wells means that the trigger to change the failed instruments is usually the necessary choice.

Casing failures (930 hours - 39 days): An event that cost a significant period of downtime: Failed work of 9 5/8" extensible on well 3 (39 days): Attributed to overloading the first 6 jts of SET. The fountain flowed during the expansion process. The event eventually led to the circumvention of the wells.

Locked recording tools (760 hours - 32 days and currently in progress on well MAT): Always a risk with MDTs Severe impact on MAT wells, leading to two secondary routes.

Bottom loss (507 hours - 21 days): Consistent with the narrow edges of PP / FG In many cases, accompanied by good control situations and causes more downtime than the pure case "only losses".

Surface equipment failures (383.25 hours - 16 days): Multiple failures. The top factor is the running gear of the housing (50 hours - 13% of all surface failures), followed by the failure time on surface DST equipment. Minor time for cutting equipment and cement pump and other surface kits.

Cable recording problems (266 hours - 11 days) are tool failures. It is currently implementing a BP audit process to improve pre-employment QA / QC checks.

Figure 9 shows another category of NPT based on type. There are two types: bottomhole problems, and bottomhole failures. Figure shows the percentage of each type of NPT.

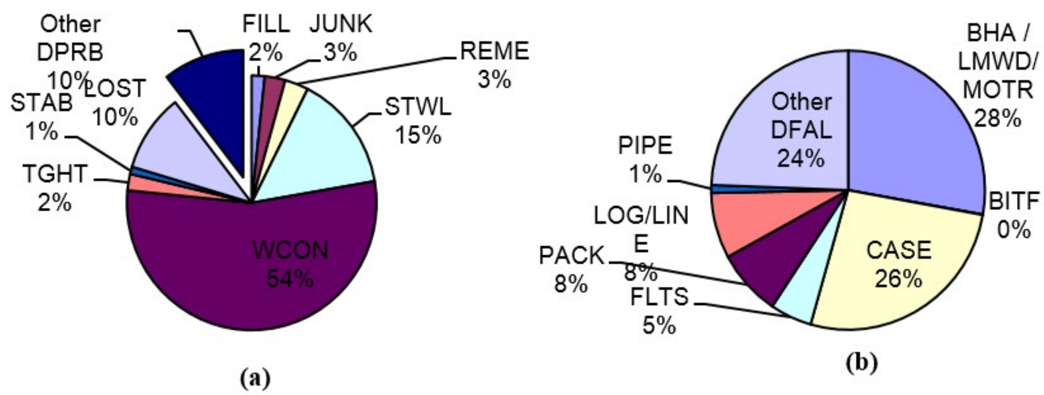

Figure 5. (a) Problems at the bottom of the well (b) Bottomhole failures.

IV.CONCLUSION

HPHT wells have several problems which appear during and after drilling operations. Here, our study is to analyze and categorize most these problems. Moreover, a benchmarking study was implemented so as to compare between our wells and the offset drilled wells regionally and globally. Therefore, the following conclusions are extracted based on our results and discussions:

1. NPT analysis is a vital tool to identify most of the HPHT drilling and operations' problems.
2. Benchmarking is also an important method in order to know the drilling performance of HPHT wells.
3. Most of the lost time lost during drilling is due to rig repairs and well control.
4. Some wells from our study showed a better performance in comparison with those drilled locally and globally.
5. In order to reach BW performance, total NPT should be reduced and all offset problems should be overcome.

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V. REFERENCE

[1] L. Lake, F. M. Robert, ‘‘Petroleum Engineering Handbook - Drilling Engineering,’’ SPE volume II, 2006.

[2] M. Halafawi, L. Avram, "Wellbore, BHA, Motor / Rotary Steerable, and Bits Statistical Performance Analyses for Drilling Horizontal Wells," Petroleum - Gas University of Ploiesti Bulletin, Technical Series . 2019, Vol. 71 Issue 2, p47-54. 8p.

[3] G. Mensa-Wilmot, S. Southland, P. Mays, P. Dumrongthai, "Performance Drilling—Definition, Benchmarking, Performance Qualifiers, Efficiency and Value," SPE/IADC Drilling Conference and Exhibition, March 17–19, 2009. DOI:10.2118/119826-MS

[4] S. H. Zafar, G. Akinniranye, "KPI Benchmarking—Asystematic Approach," 2009 National Technical Conference & Exhibition, New Orleans, Louisiana, AADE 2009NTCE-07-04.

[5] T. Eren, M. Kok, "A new drilling performance benchmarking: ROP indexing methodology," Journal of Petroleum Science and Engineering, 2018:163, pp.387-398.