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Optimizing Drill Bits Performance in Highly Unconfined Compressive Strength Formation, Sinai Oil Field, Egypt

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***Abstract*: In Belayim Oil field, Sidri concession, 8 1/2" section is composed of conglomerates with overall Unconfined Compressive Strength (UCS) varies from 25,000 to 40,000 psi.**

This section was mainly drilled with Polycrystalline Diamond Compact (PDC) bits and Tungsten Carbide Insert (TCI) drill bits. Drilling 1000 meter in 8 1/2" section needed minimum 6 to 8 drill bits. The average rate of penetration (ROP) was 2.8 (meter per hour) MPH and the average drilled interval was 135 m. The rock bit that had been used in offset wells achieved low ROP and short drilled intervals as well, meanwhile, PDC bit achieved moderate average ROP and relatively short run intervals

The operator target was to reduce the drilling time by raising ROP and the drilled interval per drill bit; the hybrid bit was presented to achieve that target.

The hybrid bit achieved the highest ROP record and the longest drilled interval in Sidri concession achieving 200 percent improvement from offsets' average performance.

Finally, the paper recommended using three hybrid bit in the first three runs and in the fourth run, where the unconfined compressive strength reached its maximum values, TCI drill bit could be used.

***Keywords*: Conglomerate formation, High unconfined compressive strength formation, Hybrid drill bit, Drill Bit optimization.**

I. INTRODUCTION

As the objective of the drilling operation is to safely execute the drilling plan at optimum performance with minimum cost and time. The operators are continuously looking for techniques that maximize operation efficiency and minimize the time to drill each section. [1]

This can only be achieved by optimizing the drilling efficiency through three distinct phases; planning and modeling before drilling, monitoring during drilling and analysis after drilling. Therefore, the challenge between the drill bits manufactures is rapidly increasing to achieve the operators' target in optimization efficiency. [2]

It entailed intense great competition among the major manufacturers bringing continuous development in drill bit technology. Drilling in deeper more harsh conditions well requires more advanced drilling technology and equipment. Therefore, the efficiency of drill bits is increased by improving their quality and this will allow a further increase in the rate of penetration.

8 1/2" hole section in Sidri Concession is considered the most difficult challenge to the success of the entire wells. The challenges in this section are a lot; the high unconfined compressive strength of conglomerate formation that varies from 25,000 to 40,000 psi, the torque fluctuation, the high vibrations that were being generated when PDC bits had been used and finally the high bit wear in a short time. In addition to the previously mentioned challenges, the operator was suffering from the high cost per every drilled meter and the time consumed in drilling that section.

TCI drill bit had drawbacks during drilling of this formation such as the low rate of penetration that increased the cost per foot without achieving the optimum performance, moreover; due to the high unconfined compressive strength and consequently the high generated torque, bearing failure had occurred several times.

Each drill bit type has its own strengths and weaknesses, therefore each is suitable for specific applications. Sometimes, specific technology matches well to the application, and it is the ideal solution. [3]

Hybrid drill bit technologies produced a new generation of drill bits. The hybrid bit could combine roller cone bit and PDC bit in one. Hybrid bit combines the best of the two drill bits, using the high drilling performance of diamond PDC bit and the stability of roller cone bit. It also combines the formation crushing action of the Roller cone bit and the shear cutting action of the PDC bit. The rolling cones are positioned partially towards the back of the blades in order to open up a bigger junk slot for cutting evacuation. [4]

II. METHODOLOGY

The challenges in drilling 8 1/2" hole had been faced by implementing the new hybrid drill bit. 8 1/2" hybrid drill bit had been used in multiple wells, and through comparing the drilled intervals, ROP and the cost per meter with offset wells, and through monitoring the optimum drilling parameters, it had been observed that hybrid bit achieved all the operator targets.

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Analysis of the offset wells drilling performance is the major factor to attain the optimum drilling performance.

We can present study and recommendations based on cost per meter equation for all drill bits that had been used in the offset wells "equation (1)". In addition to analysis of the offset wells drilling performance, monitoring the drilling parameters played an important role to face the challenges during drilling the highly compressive strength formation and avoid drilling problems such as; drill string vibrations and directional tools failure.

$$c = \frac{B+(T+t)*R}{F} \qquad (1)$$

C: cost per meter ($/m)
B: refers to bit cost ($)
F: refers to drilled intervals
R: Rig cost per hour ($/hr)
T: Trip time (hr)
t: rotating time on bottom (hr)

III. APPLICATIONS AND MAIN RESULTS:

From the beginning of the new hybrid bit run, it was observed that the new drill bit drilled with lower torque fluctuations compared to the drilling torque recorded when used PDC or impregnated drill bits in offset wells, this enabled to apply more drilling parameters (weight on bit and revolution per minute), the reduced torque helped in maximizing the on-bottom hours and achieved high ROP as well.

The optimum drilling parameters had been selected to keep away from high vibration and torque fluctuation, and this had been achieved by monitoring drilling parameters in several runs. Compared to PDC Bits, the hybrid bit had lower and more consistent drilling torque, better directional control, improved durability and reliability in hard formation, less torsional vibrations and higher overall ROP. Compared to conventional TCI bits, it had increased ROP potential, less axial vibration, lower weight on bit requirement and higher overall ROP.

A. Offset Wells Analysis:

In well-A and well-B TCI rock bits, PDC bit and Impregnated bits had been used with different bottom hole assemblies; rotary, steerable and rotary steerable bottom hole assemblies, the two wells were analyzed by comparing the rate of penetration, the drilled interval per every drill bit and using the Cost per meter equation.

A detailed study of two offset wells was conducted to provide a benchmark for the hybrid bit performance. The analysis of each 8 1/2" section for the three wells is formulated in table-01.

- The two sections of the offset wells were drilled with TCI rock bits, PDC bit and Impregnated bits.
- The ROP ranges for the two wells were 1.9 – 4.8 meters per hour where the average ROP was 2.8 meters per hour.
- The drilled intervals values were 79 – 183 meters per bit.
- Two core runs (type: C13146C) had been run and these two runs and the two previous runs had been excluded from the analysis.

The 8 1/2" section of offset well-A was drilled with seven drill bits had been used, five TCI rock bits, one PDC bit and one Impregnated bit, the maximum ROP was 3.9 MPH and the lowest cost per meter was 668.3 $/M, shown in "fig.1".

The 8 1/2" section of offset well-B was drilled with seven drill bits; four TCI rock bits and three sting blade PDC bits; the longest drilled interval was 183 m, the highest ROP was 4.8 MPH and the lowest cost per meter was 705.4 $/M, shown in"fig.2".

In well-C, where hybrid drill bit was run for the first time, 8 1/2" section had been drilled with five drill bits, three hybrid bits and, two sting blade PDC bits, shown in "fig.3".

The first bottom hole assembly was a hybrid bit on rotary steerable assembly, the hybrid bit drilled with lower torque fluctuations when compared with the PDC bit of the offset wells. This reduced torque provided the possibility to apply more weight on bit. The torque fluctuated only when revolution per minute exceeded 110 RPM. This allowed drilling that interval with faster drilling rate and with longer drilled interval.

The second and third bottom hole assemblies were rotary steerable on sting blade PDC bits.

The two drill bits achieved smaller drilled intervals than hybrid bit. The fourth drill bit was Hybrid bit and it also achieved average ROP and accepted drilled interval, as the UCS was higher when the depth increased.

Comparing the two offset wells with the third well; where Hybrid drill bit had been used; we found that the Hybrid bit drilled 581 meters in 88 hours with average ROP 6.6 MPH achieving 50 percent improvement from offset wells highest ROP, 100 percent higher ROP than average ROP of offset wells and Saved 3-4 days when used hybrid bit in 81/2" section instead of conventional TCI drill bit and PDC Bit. Hybrid Bit achieved the lowest cost per meter, 25 % of average cost per meter of offset wells, shown in table-1.

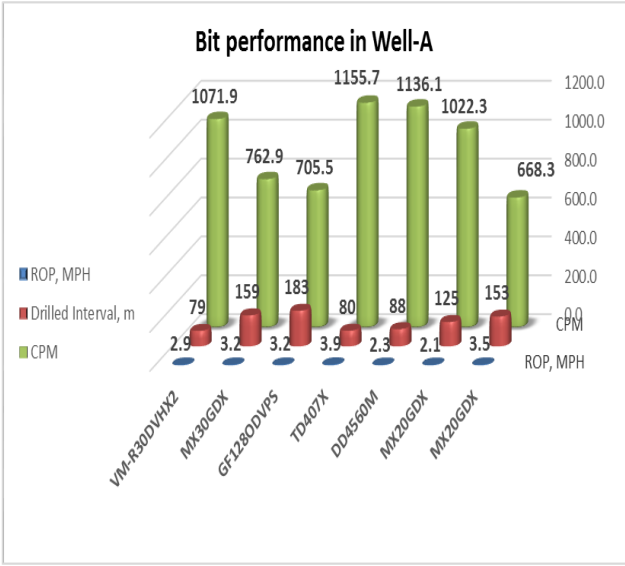

Fig. 1 – 8 1/2 inch drill bits ROP, drilled intervals, cost per meter of well-A

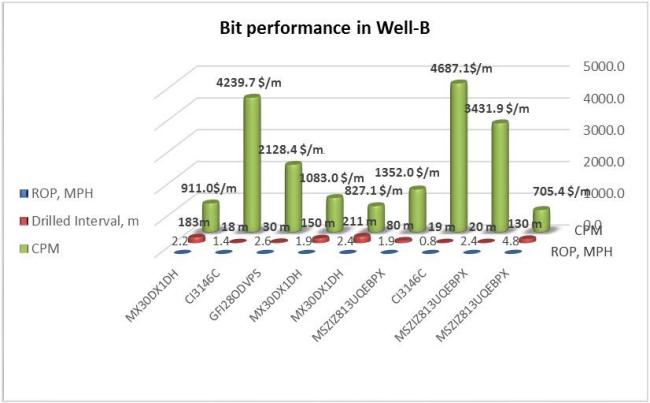

Fig. 2 – 8 1/2 inch drill bits ROP, drilled intervals, cost per meter of well-B

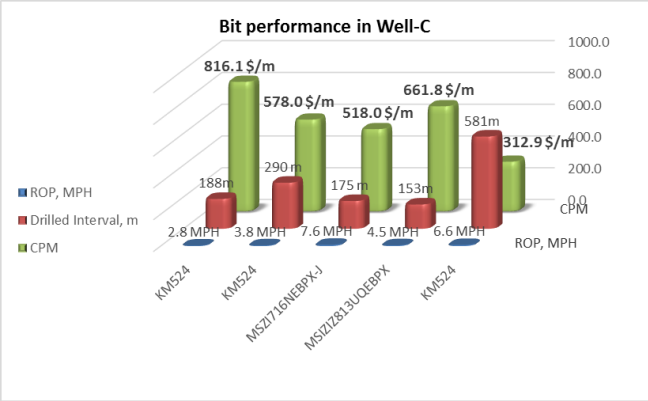

Fig. 3 – 8 1/2 inch drill bits ROP, drilled intervals, cost per meter of well-C

Table.1-8 1/2 inch drill bits ROP, drilled intervals, cost per meter of the three wells

	BIT TYPE	IADC	INTERVAL	HRS	ROP	CPM ($/M)	DULL GRADING							
WELL-A	MX20GDX	517	153	43.5	3.5	668.3	2	3	WT	A	E	1/16"	LT2,BT4,CT2	PR
	MX20GDX	537	125	60.5	2.1	1022.3	1	3	CT	G	E	1/16"	BT.WT	PR
	DD4560M	IMPREG.	88	38.5	2.3	1136.1	5	4	WT	A	X	I	HC	PR
	TD407X	PDC	80	20.5	3.9	1155.7	6	7	WT	A	X	1/8	RO,CT	DTF
	GF128ODVPS	527	183	56.5	3.2	705.5	2	3	WT	A	E	1/16"	LT1	HR
	MX30GDX	537	159	50	3.2	762.9	6	8	LT	A	E	1/8"	BT,WT,CT,SD	HR
	VM-R30DVHX2	537	79	27	2.9	1071.9	1	1	WT	A	E	1/16"	BT	TD
WELL-B	MSZIZ813UQEBPX	STING BLADE PDC	130	27	4.8	705.4	0	1	WT	G	X	1/16"	CT2,PN7	DTF
	MSZIZ813UQEBPX	STING BLADE PDC	21	8.5	2.5	3431.9	1	1	WT	A	X	1/16"	CT3	CP
	CI3146C	M844	19	23.5	0.8	4687.1	CORE							
	MSZIZ813UQEBPX	STING Blade PDC	80	41.5	1.9	1352.0	2	2	WT	A	X	1//16	CT	PR
	MX30DX1DH	537	211	89.5	2.4	827.1	3	4	WT	A	E	1/16"	NO	HR
	MX30DX1DH	537	150	80	1.9	1083.0	3	4	WT	A	E	1//16	CT5,BT3	PR
	GFI28ODVPS	527	30	11.5	2.6	2128.4	0	1	WT	G	E	I	NO	CP
	CI3146C	M844	18	12.5	1.4	4239.7	CORE							
	MX30DX1DH	537	183	84	2.2	911.0	4	4	WT	A	F	1/16"	BT2,LT2	TD
WELL-C	KM524	HYBRID	581	88	6.6	312.9	1 - 1	2 - 1	BT3 - WT	N&S - A	X - E	0.1	WT - NO	DTF
	MSZIZ813UQEBPX	STING BLADE PDC	153	34	4.5	661.8	1	1	WT	A	X	I	PN2	DTF
	MSZI716NEBPX-J	AXE BLADE PDC	175	23	7.6	518.0	1	1	WT	A	X	1/16	PN2	BHA
	KM524	HYBRID	290	76	3.8	578.0	1 - 1	1 - 1	WT - WT	A - A	X - E	I - I	NO - NO	HRS
	KM524	HYBRID	188	66	2.8	816.1	6 - 6	4 - 4	CR - CR	N,C- I&M	X - E	1/16	CT,BT,HC - BT&LT	TD

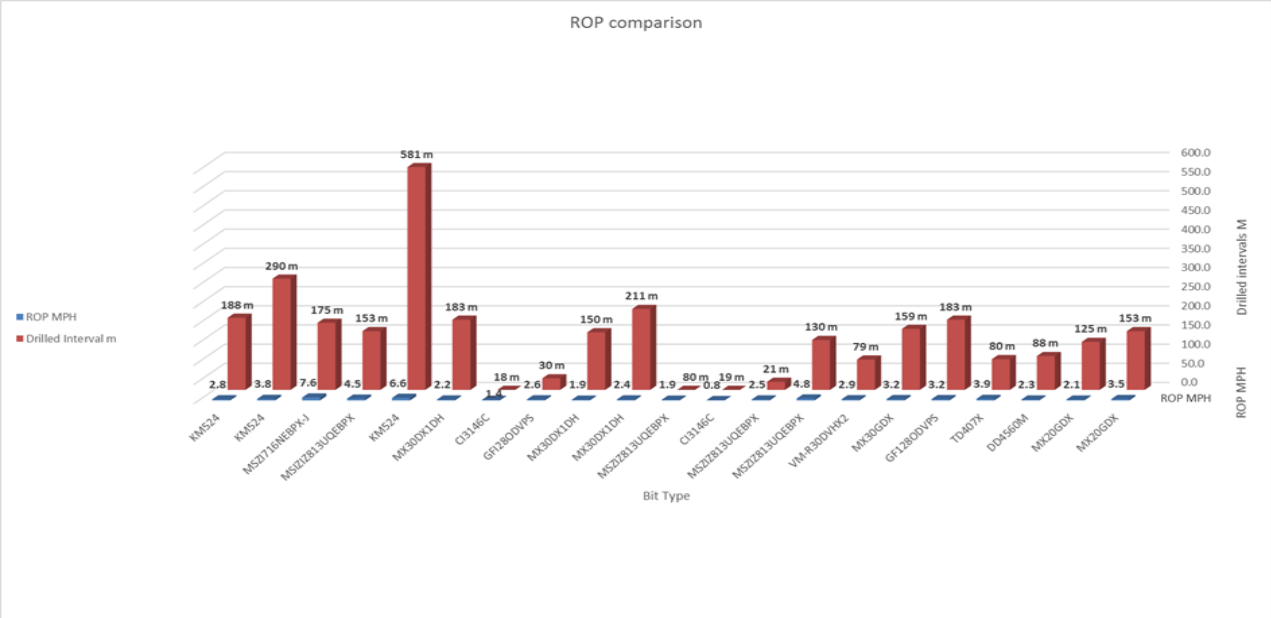

Fig.4- 8 1/2 inch drill bits ROP, drilled intervals, cost per meter of the three wells

IV. CONCLUSION

In conclusion; instead of drilling 8 1/2" phase in conglomerate formation with 7-8 TCI and PDC drill bits, the paper presented a recommendation; that section could be drilled with only four drill bits; the first three drill bits are recommended to be hybrid bits and the fourth run, where the unconfined compressive strength is very high, it's recommended to use TCI drill bit like the life time of the bearing is longer and could sustain high loads.

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Ahmed Yasin has been working in Oil and Gas industry since February 2014 experienced in drilling, completion and HSE engineering and operations.
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