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New Impregnated Bit Achieves Outstanding Drill Outs

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Abstract

Beginning with a brief overview of the drill-out techniques previously used in the field, the paper explains the specific cutting mechanisms involved in drilling out and on the design solutions that were successfully applied. Details describe how operators in Algeria were able to improve drilling efficiencies, reduce drilling costs, and improve established benchmark performance targets by applying impregnated bit technology in a historically roller cone or PDC application.

Also described are the bottom hole assemblies, incorporating either a turbine or down-hole motor, that were used in both vertical and deviated well applications.

All aspects of the operating parameters are presented, culminating in eighteen successful drill-out runs at the time of writing, establishing a new benchmark performance. The paper also gives recommended procedures for a successful 6” impregnated bit drill out operation.

Introduction

With a total market for impregnated bits of over 8 million US dollars a year, representing some 200 units sold, Algeria was a place of choice for the development of the new drill out technology.

Drilling out cement and casing equipment efficiently with diamond impregnated bits has always been a challenge to bit manufacturers. Thus, a new, impregnated diamond bit was designed for drilling out a casing shoe.

The new design takes advantage of successes with the block set cutting structure technology and is capable of drilling ahead for long sections in very abrasive formations. Utilizing the block set cutting structure technology and adapting it to the specific drill-out application has resulted in a step change with regard to established benchmark drill-out performance.

Historical Background

For many years, liner or casing float equipment was drilled out with roller cone bits. With the evolution of PDC design and technology and the introduction of “PDC drillable” float equipment, operators were then able to select their drill out bit with regards to the characteristics of the formation expected to be found when drilling ahead.

But in the case of typical impregnated applications, with very hard and abrasive formations to be drilled, the choice of drill out bit types was still insufficient.

PDC bits could not be used in that drilling environment. Hard formation roller cone bits were likely to lose inserts or to drill an undergauge hole, thus being a potential source of problems (extensive reaming, junk damage) for the next bit run.

The only option, was to run a milled tooth roller cone bit to drill out the shoe and cement , then pull out of hole for a bit change. In Algeria, impregnated bits were used to be run after drill out, to drill formation ahead.

Design Solutions

During the last quarter of 2002, an international oil company asked bit suppliers to look at the feasibility to design an impregnated bit that could, for the first time in this Algerian application, drill out the cement and 7” liner equipment, and drill ahead in the Ordovician reservoir to the well TD, thus saving a milled tooth roller cone bit with a rotary assembly and one trip.

A multidisciplinary team was set up and a development project started. The objective was to define drill out bit specific needs, new designs and materials potential solutions.

Microscopic usual cutting capability of diamond impregnated materials, is not aggressive enough to cut efficiently cement, rubber and soft metal. The team pointed out the “macroscopic cutting capability” (as opposed to microscopic), as being the key solution to enable efficient drill out.

Macroscopic aggressiveness is achieved by the use of scribe shaped impregnated cutters, in the cone and nose areas of the bit. The scribe cutters are slightly exposed over the rest of cutting structure, reducing cutting active surface and increasing dramatically overall bit aggressiveness. This feature enables the bit to drill efficiently cement, almost like a PDC bit.

A 6” impregnated diamond drill bit (Figure 1) incorporating impregnated scribe feature, was especially designed. This new design was based on the existing impregnated bit, being run in the hardest and most abrasive Cambrian Formation of Hassi Messaoud field. In addition of drill out capability, the new bit included all

advantages of latest generation impregnated bits. The bit features a full coverage of diamond impregnated segments, TSP enhanced. The segments incorporate latest technology of double phase impregnation process that produces a self-sharpening cutting effect, as well as protection from erosion and abrasion wear. The bit has a 2 inch gage and a 12 inch sleeve and is available with a pin or a box connection

In addition, for a successful casing shoe drill out with a diamond impregnated bit, the casing shoe must be PDC drillable and the recommended drill out procedures must be followed carefully. Otherwise there will be premature wear of the scribe blocks and potential drill out failure.

First impregnated bit drill out in Algeria

In January 2003, for the first time in Algeria, the cement and casing shoe equipment were easily and successfully drilled out using a turbo-drill and the new technology diamond impregnated drill bit, saving one trip and a milled tooth roller cone bit.

On this vertical well, the bit drilled 40 m of cement / equipment and 130 meters of formation to well TD at 2941 meters. The bit drilled at a ROP of 4.46 m/hr, and due to its capability of drilling the casing equipment, saved approximately 14 hours drilling time compared with the best 6-in. section. Overall savings were $38,000.

Drilling-out casing equipment with diamond impregnated bits in association with a turbine had become a reality with the new impregnated bit design.

Successes in medium radius horizontal wells - Hassi Messaoud field

Taking advantage of this first successful drill out run completed with an impregnated bit in Algeria, an even more challenging test run was planned in a medium radius horizontal well: the bit used on a steerable mud motor had to drill out the 7" liner landing collar and rubber plugs, plus cement, float collar and liner shoe, then keep drilling while building angle in the hard and abrasive sandstones of the Cambrian reservoir.

A typical medium radius well profile in the Hassi Messaoud field (Figure 2) incorporates three build-up sections. The last one, drilled in six inch diameter, requires a dog leg severity ranging from 6 to 16 degrees / 30 meters to reach the final inclination. The 900 meters long drain is drilled in the Cambrian sandstone reservoir (3400 m TVD).

The first medium radius horizontal well was drilled in the Hassi Messaoud field from December 1997 to April 1998. The 960 meters long 6” section required the use of sixteen hard formation insert roller cone bits.

In April 1999, impregnated diamond bits started to be used to drill the lateral extension, but tungsten carbide insert bits were still being used for the build-up and landing initial part of the drain.

In December 2000, for the first time, the final build section of the well was drilled using a diamond impregnated bit.

Since then, the rapid improvement of impregnated bit design and manufacturing technology led to a remarkable achievement: as an average, horizontal drains are now drilled with 5 impregnated bits.

In June 2003, the first new technology diamond impregnated drill bit, run on specialized slick steerable motor assembly (Figure 3) drilled out the 7” liner float equipment in 8 hours and 25 minutes, and drilled 169 meters of formation, building angle from 48 to 75 degrees, with an average build rate of 4.3 degrees / 30 meters.

When using an insert roller cone bit in this application, the drill out takes an average of 14 hours, and the drilled length rarely exceeds 80 meters, the average run being 40 meters.

Achievable Build-up rates

Drilling out with the new technology diamond impregnated drill bit has since become a common practice, with more than 18 successful runs in 6” and 8 3/8” sizes. This drill out technique has been used, on specialized slick steerable motor assembly with a pin connection down, or conventional steerable mudmotors or turbines. Higher build rates and longer bit runs (up to 458 meters record) have been achieved as experience was gained.

Experience has shown that when using steerable motors or turbo drills in conjunction with short gauge pin connection bits, some steering problems may be encountered. The solution is to modify the bit and drive system to smooth the bit/motor transition.

Contrary to popular directional drilling wisdom, a directional assembly incorporating a box up extended gauge bit (usually 10 to 12 inches), run on a specialized slick steerable motor assembly will increase the tool's dogleg capability compared to standard short gauge bits. (Figures 3 and 4).

Operating guidelines

The following step-by-step operating guidelines have been developed to ensure a successful drill out operation with a 6” impregnated diamond bit:

- Run in hole with, with special care when reaching the top of liner (especially with directional BHA).
- Wash down the last 2 singles to the top of landing collar.
- Confirm the true depth and pick up the string.
- Change mud if necessary. It is not recommended to start drilling out while displacing mud (the pressure and the WOB indications would be unstable and not reliable,

due to the difference of mud weights between the drill string and in the annulus.)

Once the new mud is at surface, start drilling out the landing collar:

- Tag the top rubber cementing plugs without rotating or circulating, in order to “crush” them.
- Adjust the mud motor using the tool face gauge indicator (Directional Driller).
- Start the circulation to a minimum of 200 GPM (800 LPM), giving an output of 1200 rpm for a turbine and 425 rpm for a motor.
- Start rotating the top drive or rotary table 20 to 40 rpm.
- Apply WOB up to 2-3 Klbs.
- Mark the kelly every 10 cm in order to closely follow the progress of the operation.
- While drilling cement, weight on bit can be increased to 6–8 Klbs.
- Drill the float collar with the same parameters as for the landing collar
- Maintain the parameters as constant as possible in order not to damage the bit.

Conclusions

Drilling out efficiently with diamond impregnated bits has been an elusive challenge for all bit manufacturers during last decade.

End 2002, a cross functional team came with a drill out specific design solution, based on a simple observation; diamond impregnated “micro aggressiveness” cannot efficiently cut cement, rubber and soft metal.

In order to add “macro aggressiveness” capability to impregnated cutting structure, scribe shaped impregnated cutters were developed.

More than 18 drill out impregnated bits have been run successfully in Algeria.

This new concept impregnated bits proved largely their reliability and efficiency. With an average drill out time shorter than roller cone milled tooth bits, the new technology diamond impregnated drill bit became the drill out bit choice for major oil company in Hassi Messaoud.

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Nomenclature

BHA = bottomhole assembly
cm = centimeters
DLS = dog leg severity
GPM = gallons per minute
Klbs = thousands of pounds
LPM = liters per minute
m/hr = meters per hour
PDC = polycrystalline diamond compact
ROP = drilling rate of penetration
rpm = revolutions per minute
TD = total depth
TVD = true vertical depth
TSD = thermally stable diamond
TSP = thermally stable polycrystalline (diamond)
WOB = weight on bit

References

Fig. 1- 6” new technology diamond impregnated drill bit.

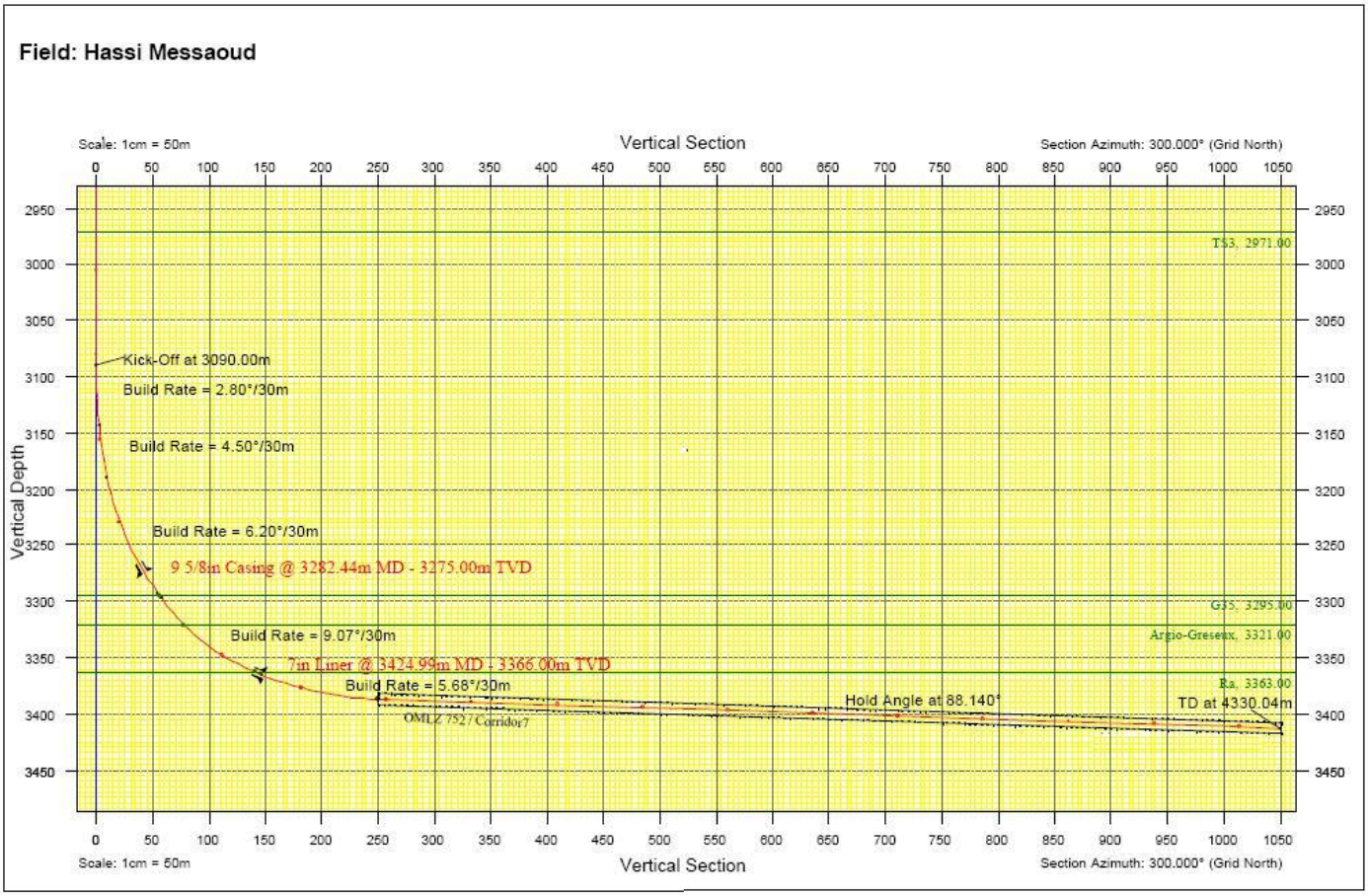

Fig. 2- Typical medium radius well profile.

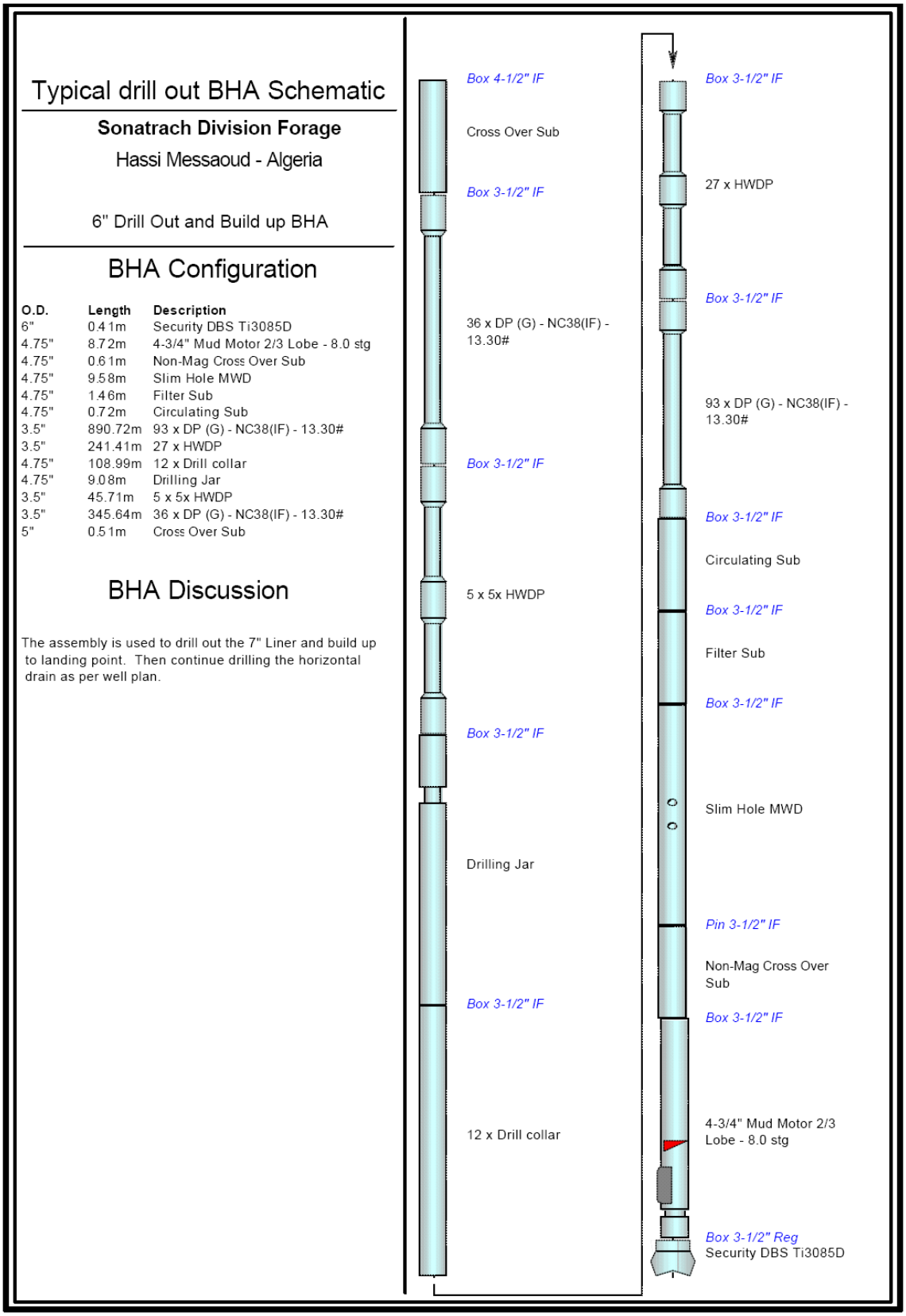

Fig. 3 – Drill out and build steerable assembly.

Bent housing (degrees)	Bit connection type	
	pin	box
1.15	-	4 to 10
1.50	4 to 6	9 to 17
1.83	4 to 10	-

Fig. 4 - Maximum Observed DLS (deg /30 m)

Run Date	Drill out time	Motor bend housing	Average DLS (deg/30m)	Maximum observed DLS	Inclination in	Inclination out	Formation drilled (m)
1-Jun-03	8h20	1.15	6.18	7.66	51.31	86.09	169
27-Aug-03	8h30	1.15	4.33	10.0	48.03	74.86	186
28-Aug-03	12h00	1.50	13.82	16.98	12.34	42.75	66
12-Sep-03	13h30	1.50	2.58	12.25	68.22	85.76	204
9-Nov-03	12h00	1.50	5.71		60.00	91.40	165
6-Dec-03	10h30	1.83	4.59	5.0	37.70	42.60	32
7-Dec-03	10h15	1.15	1.99	9.88	63.48	89.47	391
23-Jan-04	9h45	1.50	8.66	10.82	42.10	54.79	44
7-Feb-04	20h15						458
9-Mar-04	9h00	1.15	4.31	9.82	37.81	86.30	338
24-Apr-04	11h30	1.50	9.72	10.78	50.62	69.42	58
18-May-04	14h00	1.50	2.05	9.32	54.54	73.14	276
3-Jun-04	20h00	1.50	8.85	16.14	38.83	63.91	85
4-Jun-04	7h00	1.83	3.86		73.60	88.80	118
6-Jun-04	9h45	1.83	9.75		44.50	52.95	26
11-Jan-04	8h00	straight	-	-	0.00	0.00	60
25-Sep-04	?	1.50				51.07	81
8-Sep-04	?	?	5.45		72.00	88.90	93

Fig. 5 – Impregnated diamond bit drill out runs in Hassi Messaoud field