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Optimizing Operational Parameters can "Save You Money" as well as Improve Bit Life and ROP

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Abstract

With the domestic rig fleet increasing for the first time in 25 years, drilling contractors have many options to improve their fleet. But which options will deliver the best drilling performance? Oil & Gas Operators will often request that the drilling contractor supply a rig with options such as a Top-Drive to eliminate connection times or Iron Rough-Necks to lower connection times and/or improve safety on the rig floor. However, still somewhat unknown to many Operators is that a major improvement in drilling efficiency can be obtained by improving the Weight-On-Bit capabilities on the rig floor. By having an AC Drive Draw-works, Traveling-Block Monitor and Automatic Driller, these rigs are capable of keeping precise and constant Weight-On-Bit which can deliver a significant improvement in the rate of penetration as well as extend the BHA and Bit life.

In Air Drilling applications, the above rig features have been combined with down-the-hole Air Hammers / Bits to deliver excellent drilling performance and have set numerous World and Field Records. This paper will describe the details of the Innovative Drilling Technologies that are delivering "significant" drilling performance improvements to many U. S. natural gas drilling applications. Specific Case Histories will be reviewed from the Brown Bassett Field in Terrell County, TX and overall performance details will be summarized.

Introduction

The development of new technologies for drilling over the past 25 years has somewhat been designed for and limited to high profile (high cost) type wells such as directional and horizontal drilling or for deep water applications. The return-on-investment for both the service companies as well as the Oil & Gas Operator is much greater on these types of wells because of the high daily costs.

The adoption of this high-tech equipment on U.S. land-based applications have typically been slow due to the lower rig rates (daily costs). With the growth of directional and horizontal wells for land-based operations, the daily operating costs on the land-based rigs have increased and thus opened the door to utilizing additional technologies such as Automatic Drillers, Top-Drives, and other equipment that can improve drilling efficiency. This paper will describe how the use of these high-tech drilling accessories can be utilized in typical low-cost applications (i.e. Air Drilling) to improve drilling performance and save significant dollars by increasing the Rate of Penetration as well as improving bit life.

The History of Air Drilling

Air Drilling has been used in the Oil & Gas Industry since the 1950's because of the significant increases seen in the Rate of Penetration (ROP) over mud drilled wells. The reason Air Drilling is significantly faster than Water / Mud Drilled holes is because of the lower Hydrostatic Pressure. Hydrostatic Pressure creates a "chip" hold-down force that makes the bit less efficient because it has to regrind cuttings that have not yet moved up into the annulus.

However, Air-Drilled holes were typically limited to shallow wells (< 6000 feet) due to the limited Air Compression equipment (low volume and pressure) to properly clean the annulus as the well was drilled deeper. By the late 1970’s, Air Drilling was pushed deeper when larger volume air compressors and high pressure boosters were developed.

After the downturn in the Oil & Gas Industry in the 1980’s, the use of high pressure air compression equipment was somewhat accelerated by the development of a high energy Industrial Air Hammer (Figure 1) and Diamond Enhanced Hammer Bits[1] (Figure 2). In known air drilling areas such as the Appalachian and Arkoma Basins, these hammers and bits significantly increased the rate of penetration and footage and therefore reduced drilling costs in these hard rock drilling areas. This also opened the door to deeper Air Drilling applications by reducing the number of bit trips and minimizing the need to down-size the hole’s diameter because of “Gauge” wear. Many wells in the Val Verde Basin[2] (West Texas) have deeper production zones so the larger Air Packages have allowed these wells to be drilled with air to depths near 15,000 feet.

Another application that increased the use of Air and Hammer Drilling has been to reduce deviation in “Crooked Hole Country”[3]. Because Air Hammers operate with very light Weight-On-Bit (WOB), they have a tendency to keep the well-bore more vertical than other types of bits even when running a “slick” BHA (non- stabilized Bottom-Hole-Assembly).

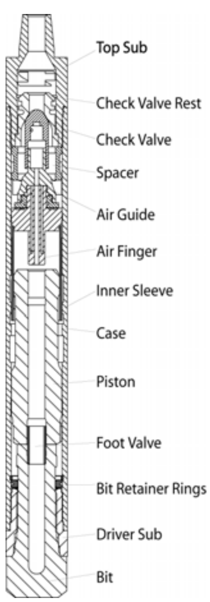


Figure 1 -- Air Hammer

Fig. 2 -- Diamond Enhanced Hammer Bit

Technology Improvement Update

Air Hammers

Conventional air hammers are designed with a Foot Valve assembly (Fig. 3) which utilizes a “plastic” tube on the top of the bit as a valve to seal the bottom chamber of the hammer. When the bottom chamber is sealed, the high pressure air pushes the piston upwards, thus starting the operating cycle of the hammer. It should be noted that the bottom chamber must be sealed in order for the piston’s cycle to begin. In other words, if the Foot Valve is missing or broken the hammer will not operate.

Although the Foot Valve mechanism has worked quite well in mining and industrial applications (Dusting), it is less reliable when operating in deeper applications due to the increased temperatures (hot hole environments; > 250°F). Therefore, the major design concept of the “Oilfield” Air Hammer[4] was to eliminate the Foot Valve mechanism while still maintaining a seal for the bottom chamber. The design also minimized the accumulation of water (non-compressible fluid) in the bottom chamber which limited the reduction of the impact energy of the piston when Mist drilling. So the development of the deep-hole “Oilfield” Air Hammer eliminated several industrial air hammer design weaknesses (i.e. Foot Valve; Figure 4) for deep hole applications and improved its reliability.

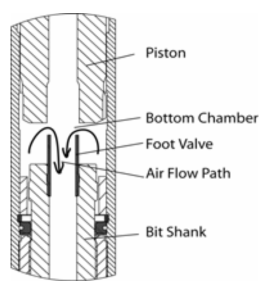


Fig. 3 Conventional Air Hammer
(Foot Valve can break)

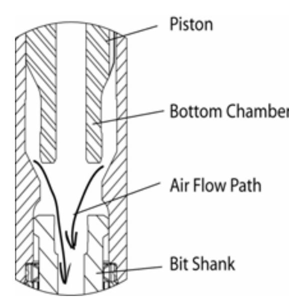


Fig 4 Deep-Hole Oilfield Air Hammer
(No Foot Valve)

NOTE: The accumulation of any incompressible fluid (i.e. Mist) in the lower chamber of an air hammer would reduce the impact energy of the piston to the bit. So the easy exhausting of the Bottom Chamber of the Deep-Hole Oilfield Air Hammer minimizes the chance of fluid building up in the lower chamber.

From a technical point of view, this design concept dramatically reduces the compression ratio of the lower chamber. In the case of the deep-hole Oilfield Air Hammer the lower chamber is compressed by 42% (See Figure 5) while the Conventional Air Hammer compresses the lower chamber by as much as 87% (See Figure 6).

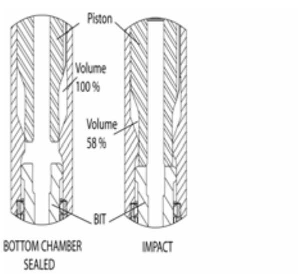


Figure 5 -- Oilfield Air Hammer Bottom Chamber Compression (42%)

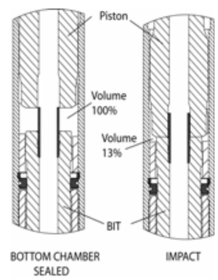


Figure 6 -- Conventional Air Hammer Bottom Chamber Compression (87%)

The lower compression ratio of the Oilfield Air Hammer will lower the pressure in the bottom chamber and thus reduce the amount of deceleration of the piston which occurs just before the impact with the bit. Thus, the piston strikes the bit with a higher velocity, which is directly related to the impact energy. Thus, the FAM-Us Series "Oilfield" Air Hammer has proven to drill faster with the same operating pressures.

In addition to the above design changes, metallurgical changes of the hammer's piston and the bit have allowed these Oilfield Air Hammers to be run with higher Air Volumes and Differential Pressures, which deliver higher impact forces to the bit. The results are typically higher Rates of Penetration (ROP).

Hammer Bits / Diamond Inserts

The general direction for Diamond Enhanced Hammer Bit design development is similar to what the industry has seen with PDC bits…………. Thicker Diamond which improves insert life.

Typically hammer bit designs have gone in two or three directions:

1) Increased insert count OR
2) Larger diameter inserts AND / OR
3) Larger radius inserts.

The high insert count bits has somewhat helped increase footage per bit. However, the larger diameter inserts (with larger radius) have significantly increased footage, without affecting ROP. Thus, the combination of these design features have improved bit performance and in many cases have allowed each section of the well bore to be drilled with one bit.

Rig Design Improvements

Variable frequency AC drives were successfully introduced to the land drilling industry on the highly acclaimed H&P FlexRig3's. The successful incorporation of these advanced value adding and enhanced capability drives with PLC based driller's controls for all 32 FlexRig3s primary drilling equipment was an unprecedented industry first for land rigs.

The AC drives and motors were specified to advance drilling performance with the very favorable speed and torque performance of the AC motors combined with the precision and repeatability of the variable frequency drives and controls.

Variable frequency controlled AC motors are able to sustain full torque at zero speed as well as supplying maximum rated horsepower over an expanded RPM range when compared to traditional DC motors. The synergistic combination of the electronic driller and the variable frequency drives provides regenerative braking capability optimum control for maximum control of fast line pay out. The PLC controlled fast line pay out is believed to deliver more consistent weight on bit and reduced drill string dynamics which improves bit or air hammer performance both increased ROP and bit life.

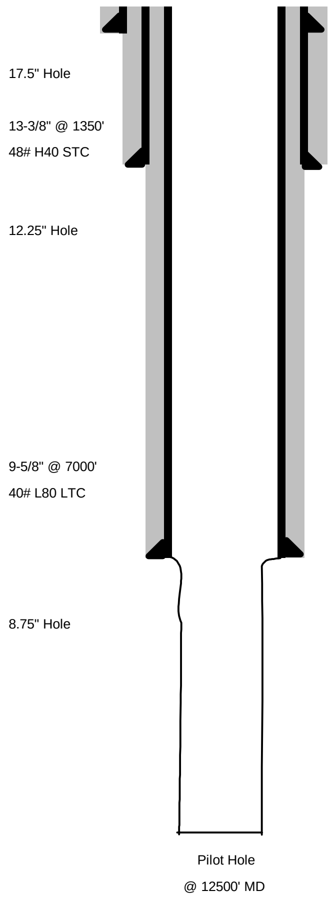
This rig is also equipped with a mechanized tubular make-up and break-out tool (also known as an iron roughneck). This eliminates the repetitive manual labor required for making up and breaking out tubulars at well center and off line at the rotating mouse hole unit. This mounting arrangement permits easy access to well center and the rotating mouse hole make up and break out tool which also included an integrated spinning wrench. This allows one man to perform with ease what has traditionally taken three men toiling with heavy manual tongs and mechanized spinning wrenches.

Further to the above H&P has deployed several new rigs with "air drilling packages" that are VFD powered with PLC control systems. We envision that this "air drilling system" coupled with other emerging technology such as continuous circulating systems and closing the loop as previously mentioned will increase the extent and limits of air and mist drilling.

Also added by the operator, are string floats. These string floats are placed every 2000' to 2500' in the drill string. This allows for a small amount of air above the floats to bleed off in a very short period of time prior to making a connection. Without these floats, connection time would be much longer.

Field Performance / Results

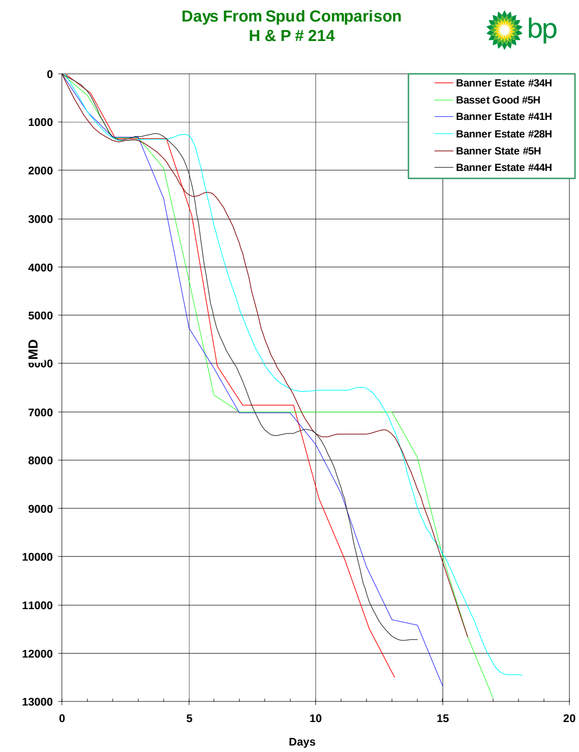
Our objective is to drill the pilot hole with air drilling technology to a depth of +/- 12,500' or 100' into the Devonian. To achieve this, three different holes sizes are needed to get to TD.



	Well #	Ft Drilled	Hours	Avg ROP
17 1/2" Hole Section				
	34H	1267	15.5	81.74
	44H	1300	18.0	72.22
	5H	1380	26.0	53.00
	28H	1357	39.5	34.35
12 1/4" Hole Section				
*	34H	5533	45.0	122.70
	44H	6072	72.0	84.00
	5H	7446	96.0	77.56
	28H	5191	67.0	77.48
8 3/4" Hole Section				
	5H	4209	44.0	95.66
	34H	5617	69.0	81.00
	44H	4271	59.0	72.39
	28H	5988	128.3	46.67

*****Terrell County, TX record for a 12 ¼" Hole.

Also note that Well #34 has the overall fastest pilot hole drilled in the field.



Conclusions

Our field data has brought us to the conclusion that numerous technological / design improvements have contributed to the continued success of this project and has "Saved Us Money" by decreasing the time it has taken to drill the pilot hole section of the wells by an average of 21%.

- **Optimized Operational Parameters**
  - Increased Air Volumes through the hammer increases impact energy on the bit and increases the ROP.
  - Use of numerous String Floats has reduced the waiting time to build-up air pressure after connections.
  - The consistent WOB / Torque capability has improved bit performance.

- **Improved Air Hammer and Bit Technology.**
  - The lower compression ratio of the FAM-Us Hammer improves efficiency which increases the impact energy on the bit.

- **Improved Rig Equipment**
  - Combination of the Electronic Driller and the Variable Frequency Drive has improved the consistency of the WOB / Torque.
  - Iron Roughneck has improved Connection Times while reducing the number of people required for making up each connection.

Acknowledgements

Finally, the authors wish to thank and acknowledge all of our companies that have allowed us to use there data in writing this paper.

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