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Realizing Higher Productivity by Implementing Air Drilling Technology For Drilling Hard Top Hole Sections in Vindhyan Fields

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Summary

Air Hammer Drilling is an efficient method to drill through surface hard rock especially when sufficient Weight on Bit (WOB) is a problem. Substantial cost savings (more than Rs. 10 Crores) resulted from Air Drilling application as compared with Conventional Drilling in offset wells due to higher rates of penetration on wells Nohta#1, Nohta#2 & Palaita#1 in Vindhyan Field of Frontier Basin.

The present paper will be useful for planning of future wells having top hole sections with high compressive strengths and thereby improving the Penetration Rate and reducing the overall Drilling Cost of well.

Introduction

Accelerated efforts of exploring for more hydrocarbons have pushed the drilling activities to more hostile environments. Deeper drilling depths are planned to meet the hydrocarbon needs of the country. Drilling through harder formations at deeper depths results in poor penetration rates and becomes uneconomical too. Air Drilling is a technique in which the more common circulating fluids, water or mud, are replaced by highly compressible air or gas. Conventional hard rock drilling is slow and expensive. Many techniques have been and are being attempted to improve penetration rates in hard rock drilling. However hard-rock conditions are ideal for air percussion drilling especially in surface holes where imparting Weight-on-Bit (WOB) is a problem.

While drilling in Vindhyan & Satpura Basin fields in Frontier Basin especially Anhoni#1 (offset well of Jhirna#1) and Jabera#1&2, problems related to poor drillabilty was faced. Drilling of top hole section has been very challenging in wells in and around areas like Jabera (Madhya Pradesh). On account of drillability problems faced in top hole sections in almost all wells, successful experience of Air Drilling on two wells Nohta#1 and Palaita#1 (Frontier Basin) assumes significant importance. This paper discusses the same in brief and compares the technique with conventional drilling of top hole at well Jabera#2 as well as provides insight to Technology and Equipment needed for Air Drilling. Significant savings of rig time and money is achieved with application of Air Drilling Technology in hard rock formations. The paper will also open vistas for planning future wells having top hole sections with very high compressive strengths for improving the penetration rate and reducing the overall drilling cost of well.

Frontier Basin wells, Jabera#1 & Jabera#2 were drilled in more than a year by conventional drilling. Realising the potential of Air Percussion Drilling in the Industry, study was carried out for its use as an alternate option to drill similar hard top hole sections of future nearby wells. The Technology, Present Industry Trends & Practices, ROP Improvement, Benefits envisaged especially for hard top hole sections alongwith Techno-Economics were worked out. Consequently 'Air Drilling Technology' was recommended and implemented on wells having hard top hole sections with formation compressive strength more than 10,000 psi. And 255m and 300m drilling in 24"diameter surface holes were successfully completed on Nohta#1 and Palaita#1 wells respectively in significantly less time by Air Drilling application.

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Performance Comparison : Air Drilling Vs Conventional Drilling

As far as Drilling Efficiency is concerned, Air Drilling on well Nohta#1 can very well be compared with conventional drilling on well Jabera#2. Drilling of 26"x 60m top hole section on well Jabera#2 took 142 days by conventional drilling as against 32 drilling days for 24"x 255m on well Nohta#1 using Air Drilling Technology as shown in Fig.A; Broadly performance can also be compared in terms of Bit Rotating Hours. Drilling of 60m of 26" top hole section on well Jabera#2 consumed 1872 bit hours by conventional drilling through, whereas it took only 198 bit hours for drilling 24" hole upto 255m on well Nohta#1 by application of Air Drilling to drill almost matching formation, resulting huge savings.

Fig. 1 illustrates savings achieved by implementing Air Drilling on Nohta#1 (255m in 32 Rig Days) vs Conventional Drilling on Jabera#2 of (255m in 134 Rig Days). Almost similar or more savings were accomplished on wells Palaita#1 & Jabera#2 by Air Drilling if compared with Conventional Drilling on Jabera#2 well drilled in Vindhyan Fields. Fig. C also shows the performance comparison between Air Drilling vs Conventional Drilling.

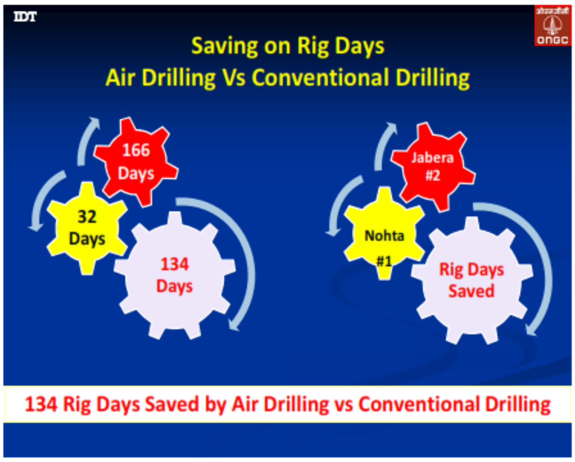

Fig 1 :Drilling through Hard Rocks : Conventional vs Air Hammer Drilling

Drilling through hard rocks is most often very costly due to extremely low penetration rates and several related aspects such as, wellbore instabilities, drill string failures, excessive trips required among others. Well Jabera was released as parametric well with an objective of acquiring stratigraphic information, thickness and source potential of Vindhyan sediments in MP and to test the hydrocarbon prospect of Jabera dome. Compressive Strengths analysis gives an idea that Jabera well formation has got very hard rock hardness in the Top Hole Section.

On analyzing graph shown in Fig. 2 (Compressive Strength Vs Depth), it can be observed that the Compressive Strength values drop below 10000psi value between 830-930m, an indication of a weaker formation that could limit the use of the Air Drilling due to the possible instability of the formation. The basic requirement for Air Drilling is that formation should be hard enough, with compressive strength of 10000 psi or more and should not be hydrocarbon bearing.

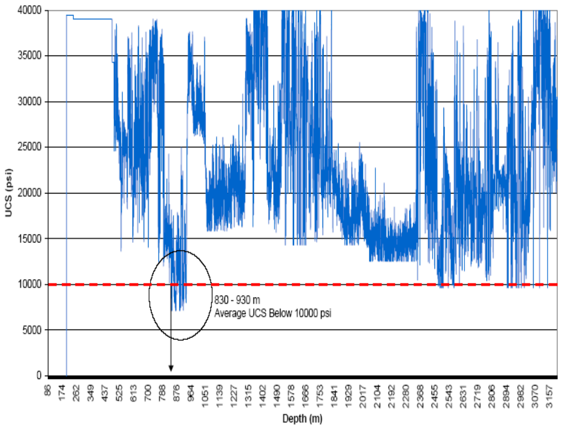

Fig.2: Compressive Strength & Depth (Jabera#1)

How Air Hammer Drilling Technology Works

In very hard surface rocks, such as granite, the only way to drill a hole is to pulverize the rock, using a rapid-action pneumatic hammer, often known as a 'Down-the-Hole Hammer' (DTH). Compressed air is needed to drive this tool. The air also flushes the cuttings and dust from the borehole.

In air hammer drilling, compressed air is pumped through the drill stem to an air hammer in the borehole. The air flowing through it actuates the hammer. The percussion air hammer drills by shattering the rock. The pneumatic bit strikes the rock very rapidly. The harder and more brittle the rock, the better the percussion air hammer works. During drilling, the drill stem is rotated (at around 10-30

RPM) to keep the borehole straight. The compressed air that escapes at the bottom of the air hammer carries the pulverized cuttings to the surface.

In air percussion drilling[1], the drilling action is achieved by incorporating a hammer tool in the BHA, immediately above the bit (Fig. 3). It takes energy from the fluid flow and uses this to drive the bit down to impact the rock, lift the piston, drive it down again, and so on. The action of air hammers can be compared to the action of a chisel and a sledge hammer.

Typically, the pressurized air travels down the hole through the drill string, passes through the hammer and drill bit, and returns to the ground surface carrying the drill cuttings in the wellbore annulus. At the ground surface, the cuttings are typically discharged through a blooie (Gas bleed-off) line to a waste pit.

Percussion drilling is normally used while drilling with dry gas, mist or foam. A water mist and foaming agents (surfactants or soap) can be added to the air stream to assist removal of formation water and reduce the risk of downhole fire. Surface hard rock cannot be drilled by conventional rotary drilling as enough WOB is not available during drilling of top hole sections.

The air hammer utilizes an internal piston (or hammer) that is actuated by the compressed air (or other gas) flow inside the drill string as shown in Fig.B. The internal piston moves up and down in a chamber under the action of air pressure applied either below or above the piston through ports inside of the air hammer. In the downward stroke, the hammer strikes the bottom of the upper end of the drill bit shaft (via a coupling shaft) and imparts an impact load to the drill bit.

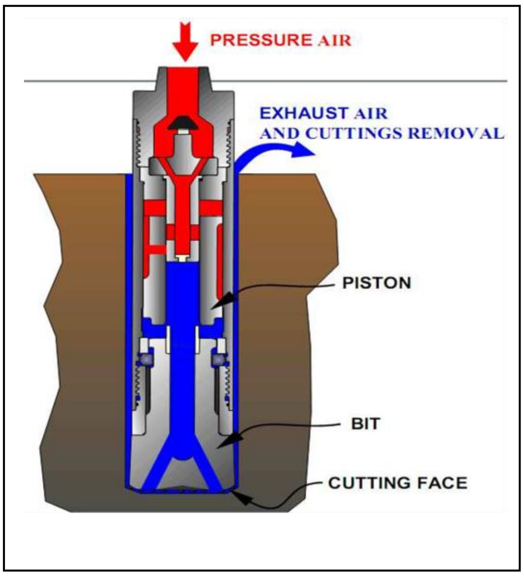

Fig 3 : Air Hammer

The drill bit in turn transfers this impact load to the rock face of the bit. This impact load creates a crushing action on the rock face. The crushing action is dynamic and is more effective than the quasi-static crushing action of tri-cone and single cone drill bits.

Equipment for Air Drilling

Surface Equipment

Primary Compressor & Booster : The compressors provide required air. The compressors take ambient air at a specific rate, compress it to required pressure or to the limit of the unit and deliver the compressed air to the standpipe and downhole through a booster compressor. Boosters are positive displacement compressors that take the exit volume of the compressors and compress it to a higher pressure. Boosters generally can increase pressure from 100 psi to as much as 5,000 psi.

Rotating Control Device (RCD) : Rotating heads are used to pack off the annulus, diverting the flow. The RCD can be either bolted on top of the annular preventer or installed on top of a conductor casing. Its main function is to divert the upstream air/gas flow from the wellbore down the blooie line to a two-phase separator or disposal pit while still maintaining effective seal between the pipe and the hole. (Fig.D)

Rotating control head[2] technology is based on applying a compound sealing rubber against the drill pipe or Kelly surface which provides an effective seal but still allows the vertical movement of the pipe.

Mist Pump : Immediately downstream from the compressors and boosters is the mist pump. The mist pump is generally a small positive displacement, triplex pump used for mist or foam applications where low rates of water need to be injected into the air stream. It is used for the injection of water and foamer for lifting cuttings when formation fluids are encountered.

Blooie line : The blooie line[3] serves to carry the returns from the RCD, away from the rig, to either the disposal pit. Regular sizes of blooie line are 8 or 10 inches OD.

Open-Top Tank : An Open-Top tank is situated at the end of the blooie line, a minimum of 35 metres away from the wellhead. This pit takes all returns from the well including formation water, mist and cuttings.

Downhole equipment :

Bottom Hole Assemblies : Generally speaking, the same bottom hole assemblies applicable for mud drilling are applicable for air and gas drilling.

Air Percussion Hammer and Bits : Air hammers with percussion bits are used world wide to drill surface hard rock. The size of the hole dictates the size of the hammer bit and air hammer Body OD. Air percussion hammers sizes to drill holes are available upto 26" (Fig. E & F).

Conclusion

It is apparent that Air Percussion Drilling application is definitely beneficial as compared to Conventional Drilling for drilling hard Top hole sections. Worldwide whether it is Middle East Region or US Region or Asia Pacific Region, hammer drilling has been proved as cost effective measure and ROP achieved by it is atleast 2 to 5 times and even more than what is achieved by conventional drilling especially in top hole sections.

- **As the rocks in Vindhyan Belt are of Proterozoic age**, the formations encountered are extremely hard. Based on the experience on wells Nohta#1, Nohta#2 and Palaita#1, "Air Hammer Drilling Technology" appears to be a fit case for "Top Hole / Surface Sections Drilling" of future wells in Vindhyan Basin.

- Air (Hammer) Drilling is an efficient method to drill through surface hard rock especially when sufficient WOB is a problem.

- Substantial cost savings usually result from air drilling due to higher rates of penetration. In most cases increases of 200 to 500% or more in ROP can be seen over that of mud drilling. This corresponds to lesser drilling days which in turn mean money saved.

- Formations susceptible to water seepage and flows make it necessary to change from straight air (dusting) to mist or foam.

- Continuous work scope with more number of wells in the same field will unquestionably yield more cost savings.

- The surface string should preferably be set covering any water table expected in the area whereby increasing the chances of successful air drilling operations.

- Straight air drilling to be resorted to initially and switched to mist/foam depending on amounts of water encountered later.

- The knowledge of geology in each well, expected formations and its compressive strength are essential for successful air percussion drilling.

- Safety is the number one concern in any drilling program. Each well should be analyzed and H2S risk level and/or shallow gas/oil occurrence determined.

- Air drilling technology is not typically suited for drilling of wildcat wells due to the risks associated with the minimal ability of air to control blowouts and to deal with weak formations and large water inflows when drilling into areas with poorly understood geologic and hydrologic conditions.

Nomenclature

DTH	Down-the-Hole Hammer
WOB	Weight On Bit
RCD	Rotating Control Devices
BOP	Blow Out Preventer
SCFM	Standard Cubic Feet per Minute
BHP	Bottom Hole Pressure
NPT	Non-Productive Time
ROP	Rate of Penetration
RPM	Rotations per Minute

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LAS profiles of Logs of offset wells for calculating Compressive Strengths.

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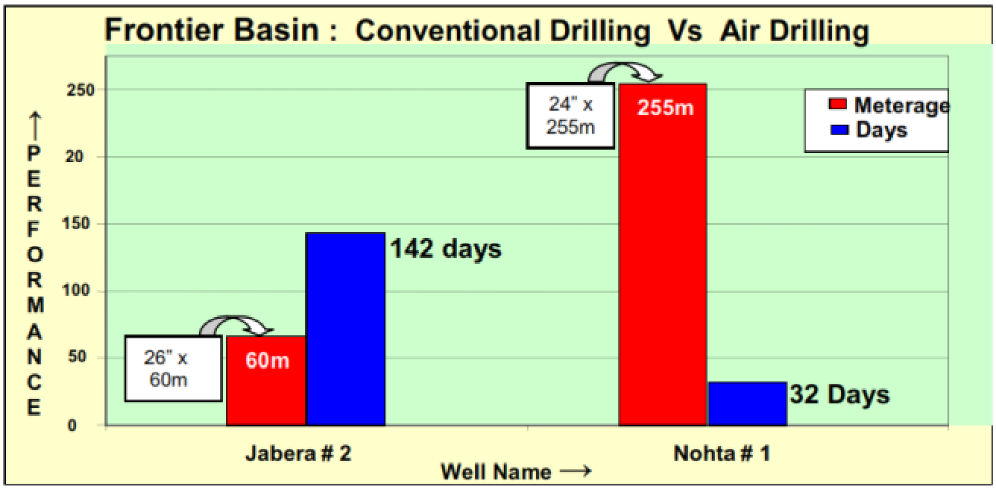

Fig A : Performance Comparison : At a Glance

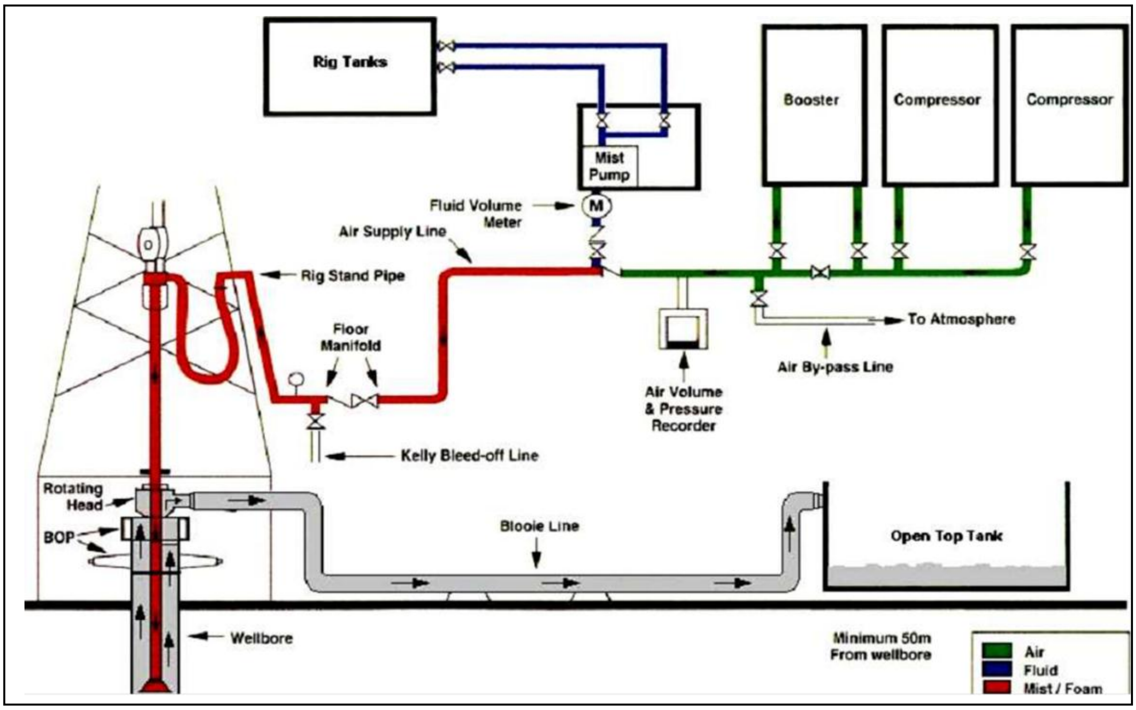

Fig B : Air Drilling Schematic

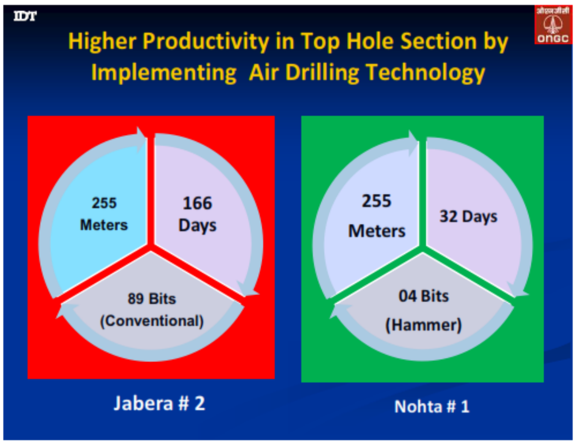

Fig. C : Conventional Drilling Vs Air Drilling

Fig E : Percussion Bit (Front & Bottom views)

Fig. D : Rotating Control Device (RCD)

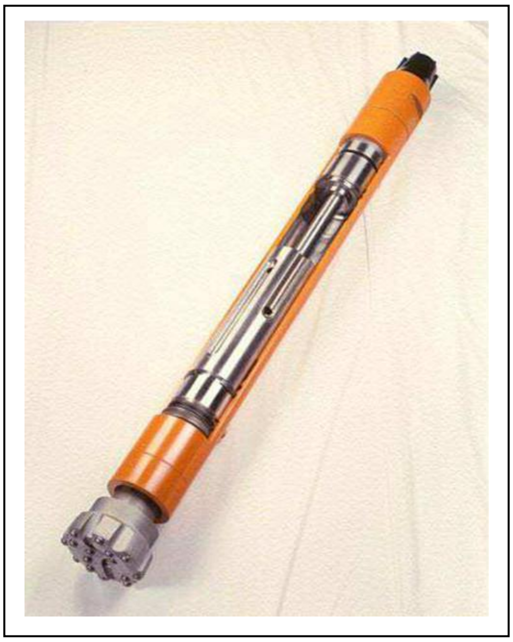

Fig. F : Percussion Hammer & Bit