L&T Technology Services

REVOLUTIONIZING DRILLING OPERATIONS: THE ADVANTAGES OF COILED TUBING DRILLING TECHNOLOGY

Industrial Machinery

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1. Introduction

Mature fields have very important role to play to meet the rising demand of Oil & Gas. The term mature fields does not have a single definition per se. Different companies might apply their respective criteria, for example, a leading company might give weightage to both subsurface and surface — when cumulative production has reached 50% of initial 2P (proved plus probable reserves) and when field completes 10 years of production. Another US Oil & Gas giant may define mature fields as the state when production has reached its peak and has started to decline.

Often the threshold decline considered is when production rates have declined by more than 50% of the plateau rate. Nevertheless, of the different forms of definition, arresting decline and increasing reserves of mature fields has increasingly become the driving force behind various ongoing innovations, experiments, and R&D projects.

Globally, about thirty major oil fields, comprising half of the world's oil reserves, have been categorized as mature fields.

Region	Number of Mature Fields	Average Years passed Since discovery/production	Estimated Oil in Place (billion barrels)
USA	15	80	245
Middle East	33	75	705
Latin America	6	50	87
Russia	30	50	134
Africa	13	55	50
Canada	5	50	4
China	5	50	43
Europe/ UK	9	35	69

Table 1 Highlights the mature fields worldwide along with estimated recoverable oil in place derived from information available in public domain. Even after considering high recovery rates of 50-60%, mature fields still hold significant reserves to meet fossil fuel demand.

Revitalizing mature fields presents a relatively low risk due to availability of reliable subsurface, production, and well data. Data play a vital role in identification and mitigation of risks involved in technology innovation and application. Besides, existing supply chain and operation framework support technology deployment, collection of sample data points and prototyping — essential to evolve technology and enhance innovation.

Major Oil & Gas companies are in different stages of recovery (primary, secondary, or tertiary) based on surface and subsurface conditions along with suitable technology adoption.

This paper covers the well development aspects of mature field development.

2. Techniques Of Well Development

Mature field development is a broad subject, however, it can be covered in two categories — well development and reservoir development.

Traditionally, mature oil fields have very old wells with aged equipment and infrastructure. Well development for mature fields consists of a wide variety of applications each intended to either restrict decline, or target new reserve such as re-entry drilling and sidetrack; horizontal extended wells; remote, real time, and wireless surveillance and control system; advanced automated drilling and completion; reduced footprint of workover rigs; and advanced materials and composite that resist high temperature, abrasion, and presence of acidic gases; and finally, the new techniques of well stimulation.

3. Re-entry Drilling / Sidetracking

Oil & Gas operators look forward to leverage existing wells and existing surface infrastructure to increase reserves. With advancements in cased hole logging it is possible to identify swept and un-swept sand intervals behind casing of old wells. These missed opportunities or prospects could be targeted by sidetrack wells or multilateral wells to tap into substantial add-in recoverable reserves.

Once a prospect is identified, casing exit milling, well placement, and designing completion dictate the drilling program along with reservoir characteristics such as net pay, oil–water contact, and adjacent formations.

4. Coil Tubing Drilling

Coil Tubing Drilling (CTD) or Through-Tubing Rotary Drilling is used to access previously bypassed pay zone economically, increasing recoverable reserves. It is used to drill sidetrack and multilateral wells through existing producing wells. CTD operation efficiency and economics depend upon Coil Tubing Unit (CTU) at surface and steering module downhole to control well trajectory.

Unlike rotary drilling with drill pipe, CTD uses continuous flexible hollow pipe reeled on drum at surface to deploy bottomhole assemblies (BHA) to target depths. Merits associated with CTD are reduced trip time, continuous circulation, no intermediate connections, directional control, high build-up rate, lesser surface footprint, quick mobilization, etc. However, there are disadvantages with CTD as well, such as, weight on bit, inability to rotate, hole cleaning, limited length, and well tortuosity.

The idea of CTD dates to 1930 and since then, it has undergone technological advancements in terms of downhole BHA technology, casing exit equipment, surface equipment, rig, and other associated services. CTD has given great operational results and economic success in regions such as Alaska, Middle East, and Venezuela — results that could have not been achieved with standard rotary drilling. Hence, although it is a niche technology there is a growing need for application of CTD as more fields mature and their production decline.

4.1 Future of coil tubing drilling

CTD is a niche technology with a history since 1930s–40s. Therefore, it may raise a question as to what kept this technology from widespread application.

There could be various replies based on economical or technological constraints. However, Scope of this paper is to share technical insight. Hence, expanding on technical insights, with recent advancements in coil tubing (CT) unit, CT downhole tools, surface equipment, slim-hole drilling tool (such as motor, bit, sensors) in size ranging from 2-3/8 to 3-5/8 inches), reservoir and well bore simulation, CTD has been gaining attention.

To fulfill the intent of operators to increase reserves of mature oilfields globally under fluctuating crude/gas price, CTD technology seems to be the technology to bank on with reduced risk. Thus, adoption rate and field application of CTD is expected to rise in the near future.

4.2 Service providers of coil tubing drilling

Traditionally Coil Tubing Units are used in Well intervention services; Well cleaning, Milling, Nitrogen services etc. Well Stimulation services- Fracturing, Acidization etc. Well perforation and Fishing. There are major oil field service companies providing Coil Tubing services having global market around 5 billion USD by 2026.

However, CTD is still niche offering available with few service companies such as Baker Hughes, Schlumberger, and Antech Ltd. With expected increase in demand of CTD, more Oil Field service provider may participate in R&D activities toward essential BHA components needed in Coil Tubing Drilling along with Automation and Prognostics. Innovations and R&D efforts will not only augment existing infrastructure of Coil Tubing services but also expand market participation by other service providers.

4.3 Bottomhole assemblies of coil tubing drilling

Main components of BHA of CTD are drilling head with CT connector, check valves, hydraulic Orienter, directional and resistivity sub, disconnect tool, and positive displacement motor with bent sub. In advanced CTD application, mono-cable and hepta-cable are used through the CT for telemetry and operate power and communication module.

Additional modules such casing collar locator, gyro, and drilling performance sub can be included in BHA as per requirement from exploration & production (E&P) operator.

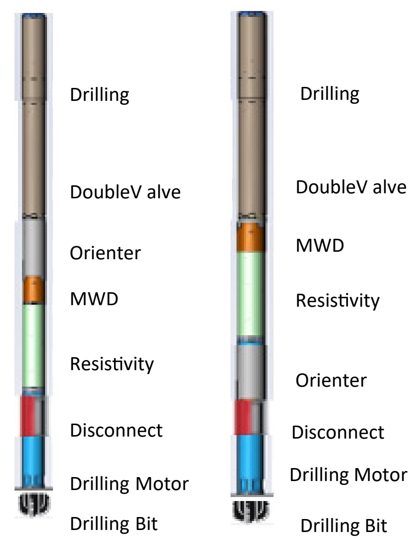

Figure 2 Illustration of CTD BHA in which Orienter module position depends on E&P operation requirement.

4.4 Function of orienter

Directional drilling needs orientation of bit in the desired direction and utilize the bend on positive displacement motor to achieve eccentricity while drilling. In conventional drilling, orientation is managed by operator from surface by rotating drill string and monitoring tool face on display connected to magnetometer and accelerometer (MWD sensor) downhole. However, CT cannot be rotated along the axis of well because of obvious reason of surface equipment such as reel, hydraulic line, manifold etc. will have to rotate in synchronization. Thus, the orienter is needed at downhole to give direction to the bend of motor. The orienter has a thread connection at both ends to give the operator freedom to select its position among other modules in BHA such as MWD sensor, Gamma, Motor etc.

Most of orienter design is based on hydraulic – either depended on drilling fluid and piston, or hydraulic control lines and piston to give rotation downhole. However, operators intend to utilize CTD in underbalanced condition to minimize well bore damage. Thus, hydraulic driven orienter may be impediment as it needs pressure cycle from surface to function.

5. Area of innovation

Electrification of Oil & Gas equipment both surface and subsurface has been the core of innovation nowadays. Major oilfield service providers' (OFS) innovation focus is on introducing electric version of old mechanical or hydraulic-based equipment. The merit here is related to sustainability goal — net carbon zero commitment of E&P and OFS companies. It also complements automation of process which subsequently generates real-time data which is further used in increasing operation efficiency.

5.1 Enhancement by electrification in coil tubing drilling

The current generation of CTD tool utilizes e-line–Monocable or Heptacable–that passes through CT, giving power and mode of communication for downhole sensors and telemetry. The orienter which steers motor is either hydraulic driven or electro-hydraulic driven. Thus, R&D toward electrification of drive that operates the orienter has advantages such as bidirectional rotation, independent of drilling fluid circulation, infinite rotational control, and calibration, repair & maintenance. All electricity-driven orienter module design will have challenges such as motor designing cooling system etc. but these could be addressed by focused R&D efforts.

6. Conclusion/ Summary

CTD has a proven track record. It provides merit over conventional directional drilling in certain subsurface conditions. Needless to mention here that CTD is not a replacement to conventional drilling.

However, with advancements in technology through focused R&D could enable development of critical BHA component such as all electric driven orienter module that improves operation efficiency and well placement such that CTD could be widely deployed in mature fields to increase reserves.

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