Recent Developments in Coiled Tubing Interventions and Design Considerations

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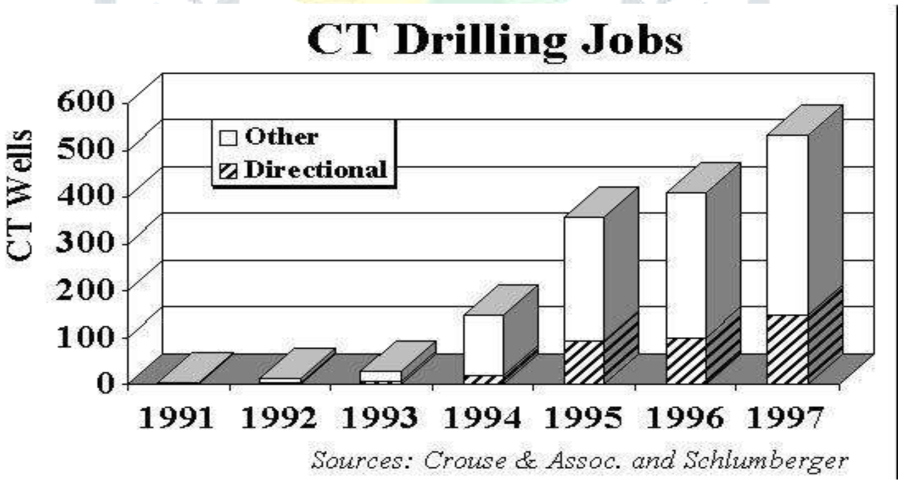
Abstract: The objective of this investigation is to study the importance of Coiled Tubing intervention and its various applications in the Oil recovery. In this research, we intend to study the various recent Coiled Tubing(CT) intervention methods and some design considerations supporting the well intervention to facilitate the better accessibility and deliverability into the oil well. This research also depicts the comparison with the existing model with the proposed model and how the proposed model enhances the capabilities to explore the well environment. In the oil and gas industries, coiled tubing refers to a very long metal pipe, normally 0.75 to 3.5 in (19 to 89 mm) in diameter which is supplied spooled on a large reel. It is used for interventions in oil and gas wells and sometimes as production tubing in depleted gas wells, sometimes as production tubing in depleted gas wells. Coiled tubing has also been used as a cheaper version of work-over operations. It is used to perform open hole drilling and milling operations. It can also be used to fracture the reservoir, a process where fluid is pressurized to thousands of psi(s) on a specific point in a well to break the rock apart and allow the flow of product. Coiled tubing can perform almost any operation for oil well operations if used correctly. It proves advantageous than the conventional drilling in respect to manpower, ease of accessibility of work-sites, cost effectiveness, time saving and also in yielding effective and precise volumes of data through continuous monitoring of the well environment.

I. INTRODUCTION

Coiled Tubing Drilling (CTD) as performed today is generally considered to have begun in 1991 with a horizontal sidetrack re-entry drilled by Oryx Energy in the Austin Chalk of Texas. From that time to the present, the technology advanced rapidly, with on the order of 4000 CTD operations completed (Figure 1). Currently, about 900-1000 CTD wells are completed a year, including about 120 directional re-entries and 800 new shallow vertical wells (many of these vertical wells are in Canada) [1]. Several key factors have contributed to the rapid rise in activity:


CT Drilling Jobs

Sources: Crouse & Assoc. and Schlumberger

Figure 1: Early Growth of CTD

- The CT service industry has achieved a level of maturity capable of providing necessary equipment and basic techniques with the required degree of reliability.
- Technical advantages exist for CTD that enable it to compete in and sometimes dominate certain “niche” markets.
- Technical advances have occurred in directional-drilling technology and underbalanced drilling techniques.

- The industry has gained greater understanding of the capabilities and limitations of CTD, enabling better candidate selection and ultimately a higher success rate.

II. INITIAL WELL RESEARCH & PLANNING

Sound CTD operations require careful and complete pre-planning and exhaustive research. The first task for the CTD project manager is to interpret the project objectives, which must be clearly defined and benchmarks established for measuring achievements.

The complete well history including a mechanical history and reservoir considerations is generated. An annotated production plot of the well highlighting fluctuations in production is needed. An updated wellbore sketch with all tubular dimensions noted as well as any problems such as tight spots, holes in tubing/casing, plugs, fill and fish left in hole should be validated by the mechanical history. Formation description of each horizon to be encountered including but not limited to bottom-hole temperature and pressure, rock properties, formation dip angle, lost-circulation zones, faults and/or high permeability streaks, and any offset well data available are supplied by the Reservoir Engineer and/or Geologist.

III. WELL RESEARCH

Well Research It is essential that all information concerning the well be freely communicated to the parties involved. The Reservoir Engineer (RE) should confer with the Geologists and ensure that the placement of the well will be optimal as well as feasible. It is imperative that the field map, reservoir isopach, and formation cross-section be reviewed in detail prior to proposing the well to the CTD Engineer. Research and discussion of the type of well needed to accomplish the objective should be fully resolved (e.g., will this be a deepening of the well, a sidetrack or a well drilled from the surface?). There are three major areas of criteria that must be considered for candidate selection:

1. Mechanical.
2. Reservoir.
3. Directional.

IV. WELL PLANNING

An information package including the research and discussion of location and target for the well should be sent to the CTD Engineer for review and preliminary study. The CTD engineer should review in extensive detail the information package, well history and wellbore sketch for any possible problems that might change the risk of the well [2]. Once it is determined that the well is a viable candidate for CTD, a preliminary directional plan should be developed by the CTD engineer and the Directional Planner. Basic CT equipment used for the majority of CTD operations is very similar to that used for CT well intervention services (**Figure 2**). In some cases, individual items may be modified or altered to suit a specific application, but generally the equipment is interchangeable between applications. The trend toward larger CT sizes in CTD often results in equipment of a size that is not easily compatible with well-intervention operations. For example, 2-in. or 2⅜-in. CT strings are not commonly used for well intervention operations [3]. A brief overview of key components (CT string, injector, reel, power pack, crane, and substructure) is provided below.

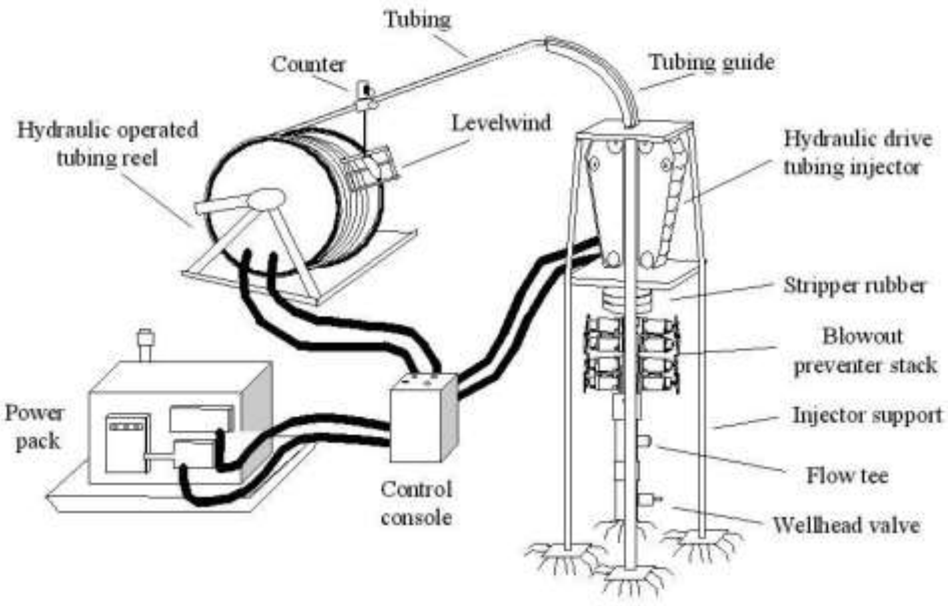


Figure 2: Basic CT Equipment Subsystems

V. CT STRING DESIGN

For new and directional wells, CT sizes of $2^{3/8}$ or $2^{7/8}$ in. are typically required. However, for some simple well deepening using a BHA with limited hydraulic requirements, a 2-in. CT string may be sufficient. Currently, most vertical deepening is done with 2-in. CT and most vertical new wells are done with $2^{7/8}$-in CT. In almost all applications, CT strings with wall thickness of at least 0.156-in. manufactured from 70,000- or 80,000-psi yield strength material are

recommended. However, for deeper vertical wells or longer step-out horizontal wells, a 100,000 or 110,000 psi yield strength material may be required. The well configuration might require the use of tapered string with wall thickness varying from 0.190 to 0.125 inches to reach the desired objective. In general, the size of CT selected for a given drilling job will be a compromise based on tubing life (smaller sizes have a longer cycle-life, but lower strength and limited flow rates) and flow area (larger sizes have greater strength and flow area, but shorter cycle life) [4]. Consequently, CTD is usually done with $2^{3/8}$- or $2^{7/8}$-in. CT. However, recent developmental work has been performed using "odd" sizes of CT to optimize performance. For example, 2⅝-in. CT has been used to drill 3¾- to 4⅛-in. hole size because it exhibited the optimal combination of cycle-life (due to lower surface pressures), annular area and flow rates for increased annular velocities and additional WOB. Another consideration is the amount of CT that can be reeled onto a given spool to achieve the desired depth or the maximum weight the crane can support. In the event that a computer model is not available, the following long-standing recommendations may be considered:

Internal pressure limits:

Maximum pump pressure while running tubing – 4000 psi

- Maximum pump pressure while tubing stationary – 5000 psi
- Maximum collapse differential pressure: 1500 psi
- Maximum recommended wellhead pressure: 3500 psi
- Maximum CT tension limit: 80% of manufacturer's published yield strength.
- Maximum CT diameter and ovality:

Maximum OD – 106% of nominal CT diameter

Minimum OD – 96% of nominal CT diameter

Running Speeds of CT:

- First time into a well - 40 to 70 ft/min
- Normal run in operations - 50 to 100 ft/min

- Spool-out depends on the well, the BHA, coil equipment, friction and operator.
- Runaway - experienced 800 to 900 ft/min.

VI. CT MANAGEMENT

The tubing-string record should include the following information (as a minimum):

- Pressure/bending fatigue-cycle history and locations of repeated bending cycling. The data for these records should be obtained from daily service activity reports or through electronic record-keeping devices [5].
- If pressure bend cycling is not recorded, then the service vendor should provide the "total running feet" (records must reflect footage into and out of the well).
- Maximum pumping pressures through the CT string when stationary.
- Exposure of tubing string to acid service. This record should list the number of acid jobs performed, type and volume of the acid system pumped, duration of the acid-pumping program, and vendor-recommended derating factors for the string.
- Locations of welds, identification of type of weld, and observations of deformity, ovality, or surface damage.
- Locations in the CT string where tensile loads exceeding 80% minimum yield were placed upon the pipe.
- A detailed record of any splicing or section removal that takes place along the length of the string.

VII. HYDRAJET HYDRAULIC FRACTURING

Hydrajet assisted fracturing is a relatively new technology combining hydrajet perforation tunnel creation and hydraulic fracturing as shown in **figure 3**. Although the hydrajet system can be deployed on jointed tubing pipes, coiled tubing, drill pipes or combination of jointed pipes and coiled tubing, the most frequent usage is with coiled tubing for multi-lateral wells [6]. Basically, the technique consists of three separate processes and that would be:

- Hydrajetting,
- Hydraulic fracturing through tubing, and
- Injection down the tubing/casing annulus.

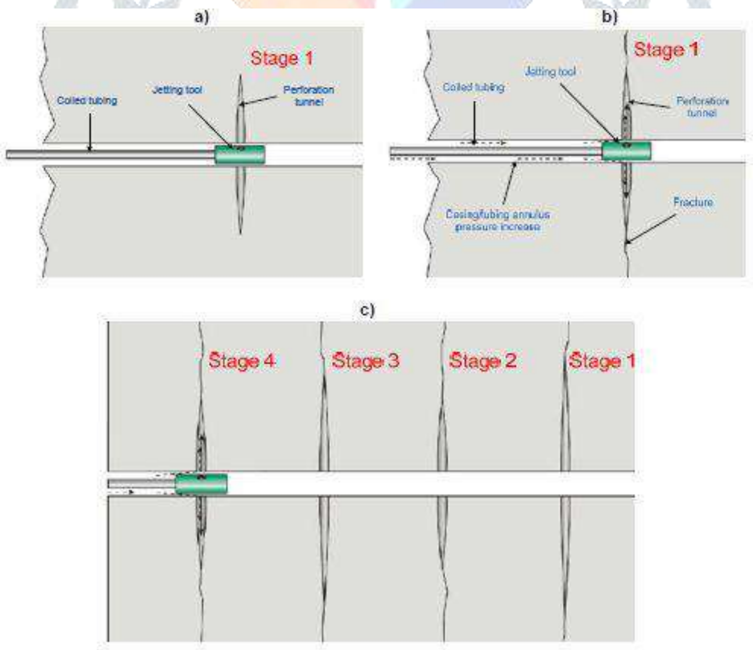


Figure 3: Hydrajet multifracturing process description

VIII. CONCLUSION

From the above study, we found that Coiled tubing is much easier way of intervening oil wells. Nowadays, many new technologies in well stimulation sector are rapidly emerging to improve operational efficiency, hydrocarbon productivity and save time and money. As described, multifracturing well completions can be deployed on wireline, jointed pipe string or coiled tubing string. So far, the most promising technique is Hydrajetting system with jetting tool deployed on coiled tubing which guarantees good movability and fast, efficient perforation and stimulation in only one run. It is useful in eliminating early screen outs caused by improper perforating with shaped charge guns. Expandable systems with swelling packers are commonly used and integrated in many advanced completions and workover production solutions. In combination with perforating and fracturing technologies and coiled tubing, they continue to expand their utilization in the oilfield. Wireline assisted stimulation is also very applicable within different well conditions, but mainly inside cased hole. Like in CT applications, one run is enough to stimulate many pay zones (depends on number of gun sets installed), but a bridge plug installation is required after every few stimulation jobs performed. To make a final decision which particular stimulation technique suites downhole environment, well stimulation simulation softwares may be used to get a broader and clear picture of the wellbore.

REFERENCE

[1] American Oil & Gas Reporter Staff, 2009: “CTD Proves Tough to Top in Right Applications,” American Oil & Gas Reporter, March.

[2] Bell, G.; Fleck, A.; Hoekstra, T.; van Beelen, N.; van Venrooy, J.; and Weihe, A., (2010): “Underbalanced Drilling with Coiled Tubing in Oman”, SPE 57571, presented at the 2010 SPE/IADC Middle East Drilling Technology, Abu Dhabi, November 8-10.

[3] DeRouen, Mark, (2009): “Wells Successfully Drilled and Completed with CT in the Gulf of Mexico,” presented at the 2009 SPE/ICoTA Coiled Tubing Roundtable held in Houston, Texas, May 25-26, 2009.

[4] Hart’s Petroleum Engineer International Staff, (2006): “Downhole Control – The Key To Coiled Tubing Drilling Efficiency,” July.

[5] Journal of Petroleum Technology Staff, (2007): “Application of Coiled-Tubing-Drilling Technology on a Deep Under Pressured Gas Reservoir,” JPT, June, page 241- 259.

[6] Lambert, M., (2000): “Multilateral Well eg Re-Entry Made Possible with a Unique Coiled Tubing Downhole Tool,” SPE 60702, presented at the 2010 SPE/ICoTA Coiled Tubing Roundtable held in Houston, Texas, April 5-6, page 124-136.