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Engineered workflow delivers strategy to fish nearly 10,000 ft of CT offshore Mexico

In an unplanned operation, valuable lessons were learned about how effective integration of conventional tools could enable the successful execution of a complex fishing operation with significant equipment restrictions.

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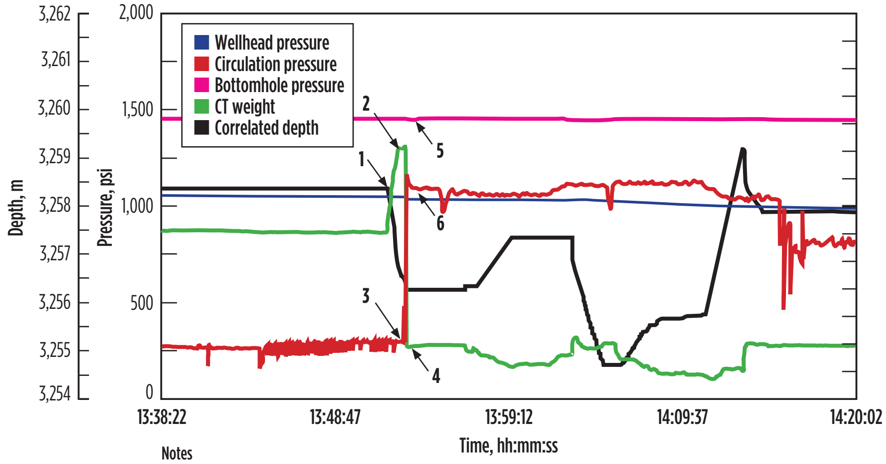
Fig. 1. During up-hole movement for the CT, the CT weight dropped to zero instantaneously.



Notes
1. CT positioned at 3,258.5 m
2. CT weight reached 36,000 lbf
3. Pump rate was increased from 0.25 to 1.00 bbl/min
4. CT weight went to 0 lbf instantaneously
5. Annular (CT tubing) bottomhole pressure kept steady before and after the pipe broke
6. CT circulating pressure was steady at 1,100 psi

In today's reality of oil recovery—evidenced by the increasing exploitation of difficult and mature fields, deeper wells and longer, more deviated laterals—interventions, and the complications often associated with them, call for new ways of thinking about solving problems. Innovation, both through embrace of new technologies and creative application of existing tools and methods, is essential to overcoming barriers in these challenging frontiers that otherwise would be inaccessible.

Oftentimes, lessons learned from trial-and-error provide the basis for developing strategies and processes that enable operators to overcome obstacles standing in the way of ambitious production expansion campaigns. In a mature well offshore Mexico, Schlumberger designed a workflow using conventional tools to execute a complex, unplanned fishing operation, extracting nearly 10,000 ft of coiled tubing (CT) that broke in the course of an acid stimulation job to boost production. The outcome, achieved after multiple runs over several weeks, involved a successful collaboration with Petróleos Mexicanos and well operator PICO Energy, and paved the way for secondary recovery efforts in the well to move forward.

Fishing operations are considered more art than science because of the all variables involved, not the least of which is whether the fishing job is planned or unplanned. Other issues that must be analyzed include the type of fish and the fishing neck (the surface where the fishing tool latches on to retrieve the damaged pipe); restrictions along the wellbore; the well trajectory; well control equipment (WCE) length and internal diameter (ID); equipment availability; the pulling capacity of the pipe; and bottomhole assembly (BHA) availability.

At that point, a well diagnosis can be performed, to determine the best fishing approach. Yet, first-time success is not guaranteed. In the challenging profiles that characterize many wells today, fishing expeditions often must be restarted repeatedly to maneuver the damaged or stuck pipe out of the hole. The key to turning a fishing nightmare into a useful learning experience with a desirable outcome is to figure out a solution that encompasses industry best practices, and applies the most appropriate tools and technologies for a particular situation.

GAS MIGRATION, DECLINING PRODUCTION

That scenario was put to the test in a mature, carbonate oil field in the Gulf of Mexico, where significant problems of unwanted gas and water production had long hindered recovery. Discovered in the late 1970s, the field is characterized by the presence of vugs, or large cavities in the rock, and an extensive network of interconnected fractures and micro-fractures with high permeability, ranging from 2 to 5 darcies. Those conditions have intensified the occurrence of gas breakthrough in producing intervals through channeling, and either partial or complete invasion of the production intervals.

A secondary recovery method, consisting of a gas-cap-pressure-maintenance program, was implemented to boost production to peak levels. This involved construction of a large nitrogen extraction plant, to capture nitrogen from the air and inject it into the gas cap, to support declining pressures. As a result, production in the field peaked in 2004 at 2 MMbopd, after which oil output declined to 1 MMbopd.

While initially effective, the recovery method ultimately led to significant gas-oil ratios and gas-oil contact invading the producing intervals, reducing oil production and leaving extensive oil reserves behind. Further acceleration of gas breakthrough across the entire play rendered conventional gas conformance methods—such as cement slurries, inflatable packers, foamed cements, gels and polymer gels—unsuccessful and costly.

Over time, the production of unwanted gas reached such high levels that surface facilities were unable to process it over an extended period. This made it difficult for Petróleos Mexicanos to comply with local and international regulations mandating a reduction of gas emissions.

CT-CONVEYED ACID TREATMENT

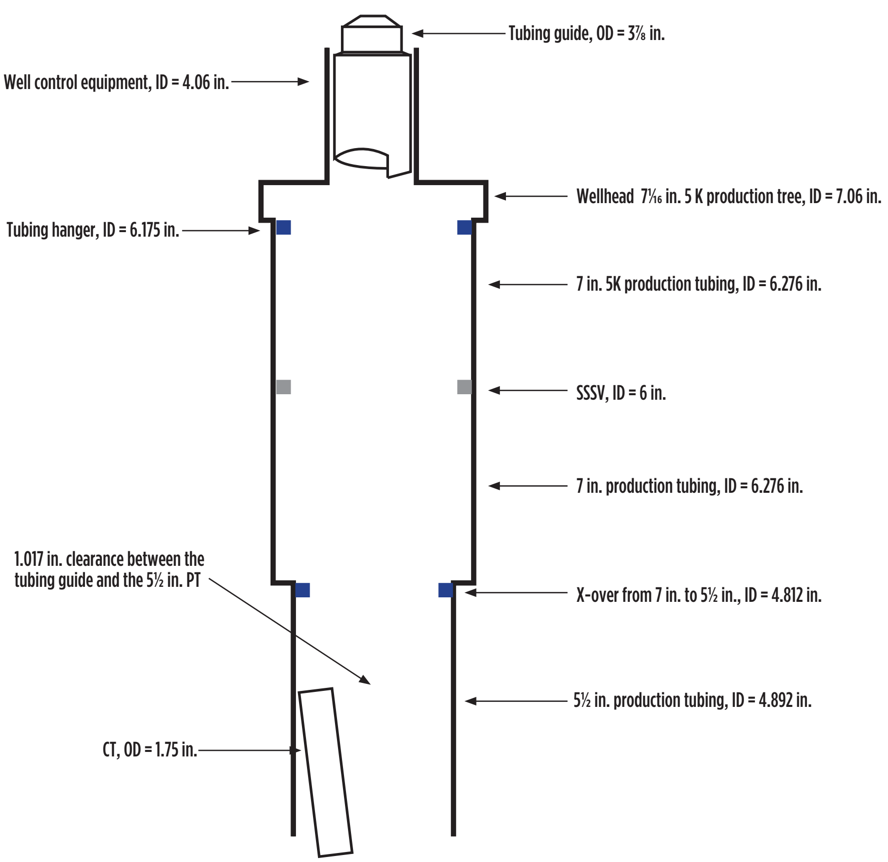
Recent technological advances have expanded the envelope significantly for overcoming these issues, culminating in a mechanical approach that integrates a fit-for-purpose polymer foam system (PFS), with ACTive* Services CT real-time fiber optic telemetry. Accurate placement and activation of the formation-penetrating PFS, prior to acid stimulation, is facilitated by CT conveyance of downhole gauges that monitor downhole pressure and temperature throughout the pumping stages. The foam seals the high-conductivity fractures that lead the gas cap to the wellbore, effectively blocking gas flow.

Petróleos Mexicanos and PICO Energy implemented the approach in a 10,669-ft well that had been closed down, due to high gas production of 23 MMscfd. The intervention's objective was to shut off the gas by bullhead pumping Schlumberger FoamSEAL* stable crosslinked foam gel. The foam creates a seal in gas-producing zones to effectively trap and stop the gas flow to oil channels, after which an acid stimulation treatment is performed, and new perforations are added away from the gas zones. Especially suited for use in naturally fractured carbonate reservoirs, the foam treatment is pumped down the annulus CT-tubing, The CT is deployed to TD, to obtain surveys that can be used to guide fluid placement and quantify fluid distribution.

After conducting a dummy run to identify potential restrictions, perform necessary clean-out, and correlate the depth using casing collar locator and gamma ray, the CT was pressurized with nitrogen and run downhole. This placed the BHA directly above the target interval, to spot the acid treatment across the perforated interval. The team used the ACTive Matrix* real-time stimulation and conformance service, which integrates tools that monitor injection rates and downhole measurements to maximize fluid penetration.

In January 2016, after reaching the TD of 10,669 ft, the pulling weight of the CT was around 36,000 lbf, the normal pulling weight reached at that depth in the previous 15 runs. However, as the operator prepared to move the pipe up-hole to place the foam at TD, a heavy noise was detected from the WCE, and the pulling weight of the CT suddenly dropped to 0 lbf. In an attempt to retrieve the pipe to the surface, the operator recovered only 653 ft of the CT, leaving 9,977 ft in the vertical section as a fish. The CT that had been such a critical component of a secondary recovery effort had suffered a mechanical failure during the initial stage of the acidizing job, **Fig. 1.**

Fig. 2. This well schematic shows CT in the 5½-in. production tubing.



AN UNPLANNED FISHING JOB

A preliminary analysis showed a fishing neck in the broken section with a 3% reduction, and a corrosion rate of 0.04 lb/ft^2 with uniform corrosion. The intervention had changed drastically from a gas conformance control treatment to an unplanned fishing operation. This operation now called for engineering a workflow using conventional tools and taking into consideration multiple variables, including a BHA with WCE and tubing restrictions of 3⅞ in.

To analyze the well condition and extent of the damage, engineers lowered into the well a 3.75-in. OD lead impression block (LIB). It was designed with a short tube fitted at the lower end and a soft lead insert that makes contact with the obstruction to create an impression. This would provide useful information on the depth of the fish and the type of fishing equipment to deploy, **Fig. 2.**

The tool initially tagged a restriction at 614 ft, with a second attempt reaching a maximum depth of 692 ft before attaching to the fishing neck. The LIB was retrieved to surface and showed that the pipe was broken and tilted on its side inside the 5½-in. production tubing with an ID of 4.9 in. This left the well with a restriction of 4$\frac{1}{16}$ in., too large for the WCE available in the country. Indexing or rotating tools would be required to increase the chances to latch.

Equipment for the job included a hydraulic disconnect; positive displacement motors (PDM); milling shoes; 60° and 22.5° mechanical and hydraulic indexing tools; an overshot tool with different OD bell guides and configurations; bent subs and bi-centric subs—all restricted to a maximum OD of 3⅞ in.

Based on the well conditions, the fishing neck condition and equipment limitations, the team's first approach to fish the CT pipe out of the well involved deploying tools to contact the edge of the pipe and guide the end of the CT inside the tubing guide. Several configurations were attempted, including mechanical and hydraulic indexing tools with 22.5° and 60° rotation; and 6° angle bent subs and bi-centric crossovers ending with the overshot tool. By gripping and applying tensile force to the fish, the overshot attempted to latch and pull the pipe loose. Various tubing guide configurations were used with the overshot, all of them unsuccessful; as shown by the same deformation mark on the LIB, indicating that the CT was still on its side over the tubing and not centralized.

Rather than reattempting to contact the tubing edge, the team opted for a different approach that involved centralizing the CT end, using a PDM and 3⅝-in milling shoe with an internal bar, **Fig. 3.** The first run using this configuration was successful. The internal bar inside the milling shoe was broken, meaning centralization was occurring, **Fig. 4.** However, this action had damaged the pipe.

A NEW APPROACH WITH SLICKLINE

Taking into consideration the deformation marks, the team next opted to use a modified tubing guide with several configurations, including a bent sub, bi-centered crossover sub and straight bars, none of which were successful. Another LIB was performed, this time by way of slickline.

In a second attempt to center the CT end, a PDM and milling shoe—equipped with an inside rod to determine if the fishing neck was latching—were deployed with a tubing guide similar to the one previously used with the overshot. This attempt prevented the CT end from getting inside the milling shoe. Deformation marks were visible on the edge of the tubing guide, and the inside rod was still in position. However, a subsequent LIB confirmed the CT was centralizing.

To avoid further damage by using the heavy, stiff CT, the team decided to attempt a new strategy, switching out the CT for more weight-sensitive and versatile slickline to fish the CT end. Several configurations were attempted, with the primary objective to latch the overshot with the fish neck and apply some compression force to facilitate clamping. The slickline was run in the hole with a mechanical disconnect, or GS profile retrieval tool, the overshot tool and a 3⅞-in modified fishing guide. This enabled the GS profile to latch onto the CT end and serve as the new fishing tool. Once the slickline fished the CT end, it was disconnected, leaving the GS profile fishing neck downhole.

CT was then rigged up with a 22.5° indexing tool and the 3⅝-in. GS fishing tool, which successfully latched the fish and began the recovery process. After a total of 43 runs over 20 days, the 9,977-ft CT pipe was recovered to the surface, with the CT weight gradually increasing from 0 to 39,000 lbf, **Fig. 5.**

With the CT fully retrieved, the blowout preventer rams were activated to secure the pipe, while some of the WCE was removed to perform surface repair of the pipe. It was determined that an OD bias weld crack was the root cause of the full tube failure. Subsequent lab analysis found that the cracks were ductile tears, possibly caused by localized buckling of the tube.

The project provided valuable lessons in how the effective integration of conventional tools could enable the successful execution of a complex fishing operation with significant equipment restrictions. By combining a PDM and milling shoe to conform the top of the fish; plus versatile and weight-sensitive slickline to effectively position the fishing tool on top of the broken pipe; and CT to latch and retrieve the entire CT to the surface, the operator was able to move forward with the planned secondary recovery campaign. WO

*Mark of Schlumberger

Fig. 3. The milling shoe, before running in hole with bar in place.

Fig. 4. The milling shoe after being pulled out of hole without inner bar.

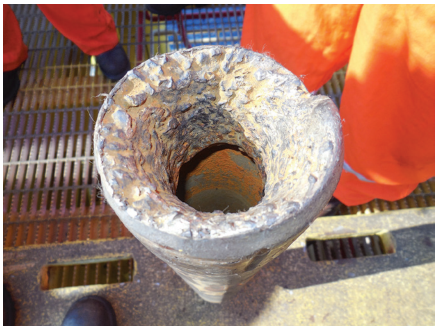
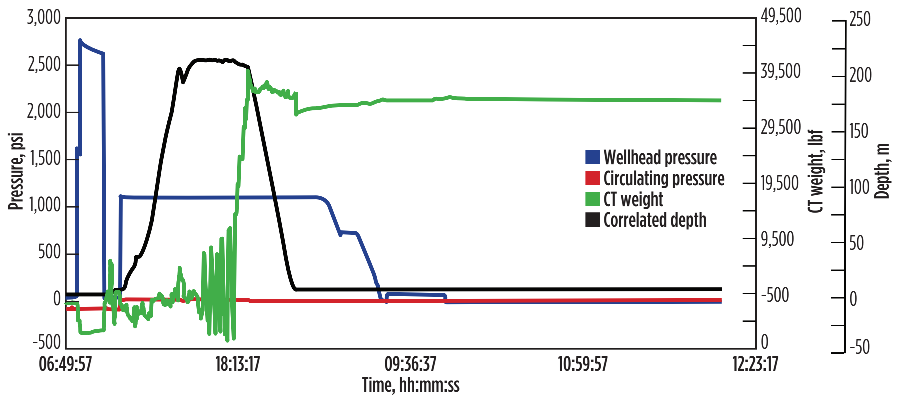


Fig. 5. During the CT recovery, it was noticed that the CT weight increased gradually, indicating a successful latch.



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