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Using Intelligent Coiled Tubing for Revival of a Double Leg Well After 12 Years of Obstruction

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Abstract

The objective of the paper is to describe successful fishing operation with Intelligent CT Telemetry System of diverter tool (16,847ft) that has been stuck in the multi-branch well in the slanted main bore section. Previous attempts to recover the diverter with slickline (SL)were unsuccessful.

The completion included a Lateral Entry Nipple at the lateral junction that enabled selective entry. The first run was planned with Venturi Junk Basket (VJB) to condition the well by cleaning top of the diverter tool. During first attempt to release diverter tool, it was discovered that a section from the Inflatable Thu-Tubing Cement Retainer (ITTCR) was left at the top of the diverter tool during water-shut-off (WSO) operations performed previously in the lateral sub horizontal bore. Thereby, additional run to recover ITTCR section and afterwards the main run of diverter retrieval was completed with the use of a TeleCoil 2-7/8″ Integrated Sensor, including a Tension-Compression-Torque (TCT) sensor subassembly that transmitted real-time axial forces applied from the surface through coiled tubing pipe.

For the first time a 2-7/8″ TCT subassembly was engaged in fishing operations to improve job execution and bring additional value to customer. The novelty of using CTT system with TCT subassembly helped to recover the diverter tool which was stuck in the well for 12 years. During both runs, against all challenges such as negligible fish weights, well deviation and buoyancy effect, the TCT sensor had detected presence of fish as additional gained weight in tension during coiled tubing (CT) pulling out of hole (POOH). The downhole loads transmitted by the pipe have confirmed that coiled tubing was more severely buckled in the well in comparison with simulation predicted values.

Furthermore, while POOH with the latched diverter tool, due to wellbore completion configuration, pull up parameters were adjusted to pass gently through restrictions based on real-time casing collar locator (CCL) & TCT downhole readings. It was another proven case history of an effective alternative option of prong & plug retrieval in challenging well conditions.

Integration of TCT sensor in fishing operations provides critical real-time downhole parameters for successful retrieval of the fish from the wellbore. Fluctuations of downhole slack off weights and additional tension of TCT tool as indication of fish release and further latch, opens the doors for other options of TCT tool utilization in coming future.

Introduction

A well in a Central Asia oilfield, was first in which both the Lateral Sidetrack and the Main Bore were completed and put on production. The well was completed as a multi-branch well, comprising a slanted Main Bore (MB) section and sub-horizontal Lateral Bore (LB). The MB was perforated (~492ft), whereas the LB was left open hole. The completion included a Lateral Entry Nipple (LEN) at the lateral junction to enable selective entry and production. Both the main bore and lateral bores have been acid washed. A routine MPLT performed in August 2006 of the Main Bore detected a small amount of water recirculation at the bottom of the well. The contribution from the MB accounted for less than 10% of the total contribution from the well when both drains were comingled. The well had a long history of water production. In November 2006 the MB was temporarily isolated (plug and diverter) to allow CT entry into the lateral bore for PLT logging. The objective of the log was to establish the source of the increasing water volume being observed at surface. The source of the water production was identified in 2006 as the LB. The diverter was subsequently found to be stuck. Access to the main bore since that time therefore was no longer possible. A few WSO attempts were performed where each had resulted in a loss of oil potential and water cut remained unchanged. It was concluded that no further attempts of WSO in the lateral bore should be performed. The well since that time was shut-in and had been so for 12 years.

The MB was isolated via a plug in the nipple at 16,958.7ft and a diverter plug at 16,847.1ft. An attempt to recover the diverter plug in 2007 with 0.125″ SL failed. The well has been re-opened in March 2018 via high phase separator (HPS), after many years of shut down, showing 5-20% WC. Based on poor LB performance it was recommended to recover diverter, in order to isolate the LB and regain access to the MB and assess MB performance. Therefore, it was proposed to utilize 1.75″ CT telemetry system with coiled tubing conveyed fishing assembly to retrieve the diverter with modified overshot pulling tool c/w hydraulic spear. The scope of work (SoW) involved a number of SL interventions as well as a dedicated CT clean-out runs prior to proceed with diverter retrieval operations.

The presented well in the paper was completed with completion shown on Fig. 1.

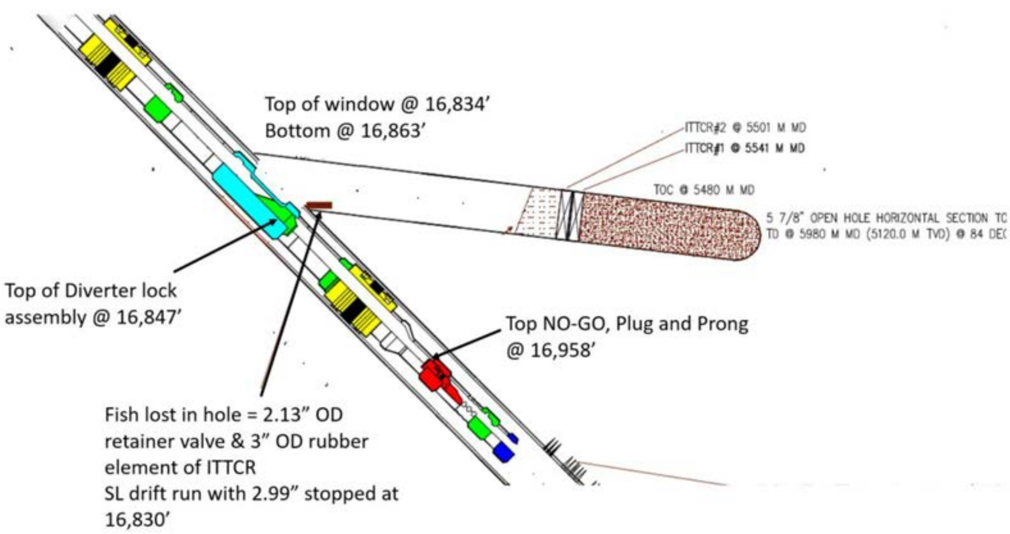

Figure 1—Well Completions

Some of the additional challenges for the retrieving on the diverter tool, were the trajectory with 51.60° and 9.30°/100 ft of dogleg severity in LB as per survey seen on Fig. 2, and the job execution done in shut-in conditions due to operator's limitations to handle sour water-based fluids at surface have contributed to complexity of operation. Seven runs were completed with 1.75″ CT telemetry system which included customized bottomhole assembly (BHA) that transmitted in real-time internal (i.e., inside BHA) and external (i.e., outside BHA) pressures and temperatures, and casing locator (CCL) data to surface through non-intrusive 1/8″ wire installed inside CT. Thereby depth was correlated according to CCL readings in runs performed with CTT System. Throughout the entire CT operations H2S inhibitor slugs were pumped during job execution due to sour well conditions. Well revival sequence of interventions included total 10 CT runs, that are described below in details.

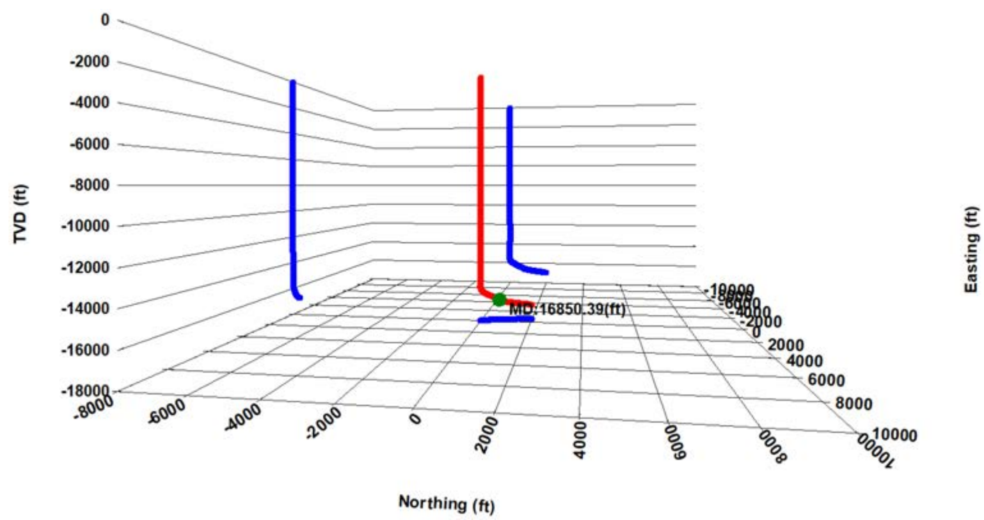

Figure 2—LB Well Trajectory

Coiled Tubing Telemetry System

Extended application of coiled tubing telemetry systems either with fiber optics or wire have been acknowledged by industry for decades. CTT system has proved itself to be an effective advantage that brings value by transferring real-time downhole data such as CCL (depth correlation), annular / tool pressure and temperature and more recent development of TCT tool (force and torque). Downhole data is being transmitted from BHA sensors to surface either by a 1/8-in. insulated electrical conductor or an optical fiber. The key difference between these two transmission applications is power delivery to downhole sensors. 1/8-in. encapsulated electrical conductor wire continuously transfers power from surface to downhole sensors and recorded real-time data from downhole sensors to surface acquisition system. Whereas fiber optics is only able to deliver data from downhole to surface, i.e. and requires BHA batteries to power its downhole sensors. As a conclusion, the main benefit of 1/8-in. wire is unrestricted time limitation due to no dependance on battery life, in contrast the main advantage of fiber optics that it records distributed temperature along coiled tubing string (DTS). Furthermore, should be taken into consideration, smaller weight of the wire, ability of ball circulation due to minimal cross-sectional area as per Fig. 3, no risk of getting ball stuck and minimal impact on CT flow pressure drop (Livescu et al. 2015a, b).

Figure 3—Insulated Wire inside 1 3/4-in. CT vs Hepta Cable

Description of the 1/8-in. Tube CTT System

Main components of 1/8-in. tube CTT system are: 1/8-in. non-intrusive electrical conductor wire Fig. 3 which is installed inside CT, surface hardware and software, and three types BHAs with varying sizes: 2 1/8-, 2 7/8-, and 3 ½-in. Surface end of wire exits CT reel through bulkhead that provides metal to metal external seal. The tool configuration may vary depending on the purposes of operation and may include either sensor package, a logging adapter or camera adapter (Silviu Livescu at al 2016). Later developed TCT subassembly could be added as a part of main sensor package.

Figure 4—1/8-in. tube wire

The main BHA includes two components as per Fig.5: top part headup which is the same for all CTT applications and bottom part which is being selected for specific operational requirements. BHA could either consist sensor assembly, camera or logging adapters, technical specifications of each provided by (Livescu et al. 2015a,b). Integrated sensor motorhead transfers CCL, external and internal pressures, and temperatures. Logging adapter configuration enables connection of 1/8-in. tube wire with logging tools. The camera adapter may include one or two cameras (front and lateral views) with ability to wash camera lenses through front and back flushing sleeves (Livescu et al. 2015a,b).

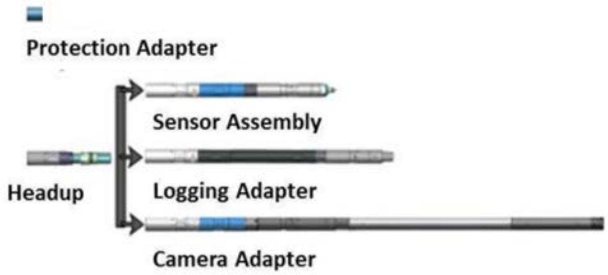

Figure 5—2-7/8-in. CTT BHA

Description of the TCT Subassembly

The 2-7/8″ TeleCoil Tension Compression Torque (TCT) Subassembly is an addition to the 2-7/8″ TeleCoil Tool, enabling real-time monitoring of axial forces (pull / push) and torque. The unit is self contained when installed into the TeleCoil Tool, outfitted internally with sensitive electronics, and therefore, it cannot be exposed to any fluids while handled and stored.

The TCT provides real-time monitoring of external mechanical forces working on the BHA. There is continuous data transmission to the operator's computer through the existing connection to the e-module of the TeleCoil Tool. The firmware algorithm of the TCT compensates for possible significant hydraulic forces, resulting in an output on the operator's screen of only mechanical loads. These loads are Tension (pull or push/compression) and Torque.

Fig. 6 TCT module housing.

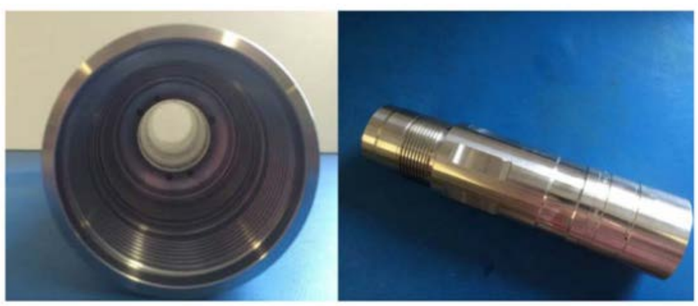

Figure 6—TCT module housing

The TCT electronics as per Fig. 7, utilizes pressure transducers in order to compensate pressure differential. Downhole axial operating limits for compression, tension and torque can withstand up to 30,000 lb and 1,500 ft-lb, respectively.

Figure 7—TCT electronics

Operational Benefits of TCT Assembly

Milling Optimization:
Acquired TCT torque downhole data enable to correlate milling parameters in order to optimize WOB to extend mill and motor life, thereby decreasing operational costs and time of intervention. Moreover, TCT readings allows differentiating between milled materials such as plugs, sand, and other accumulated debris by accurately providing torque measurement.

Fishing Time Reduction:
The TCT provides crucial downhole data for successful fishing operations. Monitoring performance of jar efficiency by gaining additional either compression or tension, engagement to fish as tension increase, and rapid drop verifying fish release with further increase in tension from the initial reading reduce uncertainty and missed runs.

Extended-Reach Capabilities Enhancement

CT capability to penetrate in extended laterals depends on mechanical friction exposed by the pipe in the wellbore which eventually leads to the level where no further progress in running in hole achieved. Being able to monitor real-time tensile load from surface helps to comprehend efficiency of extended-reach technology (i.e., fluid hammer, tractor, lubricant, etc.) that is being applied, severity of CT buckling and present completion friction. Optimization of any parameters permits to achieve required outcome of CT penetration in less time and more reliability.

Cleanout Effectiveness Enhancement

Cleanouts can be challenging, particularly in highly deviated wells. With real-time torque and compression data, surface personnel could more effectively identify top of sand in deviated wellbores, helping them execute sand removal more reliably. They could also more easily differentiate between friction lockup and wellbore obstructions, reducing operational time and reducing the risk of stuck pipe.

Actuation and Position Verification

Completion sleeves manipulation and setting mechanical barrier with CTT increases certainty as we can monitor real-time data compression and tension readings. At surface precise required downhole weight could be applied to set inflatable and straddle packers. Furthermore, pulling back to have neutral WOB to achieve successful setting of casing patches.

Run I. Venturi Junk Basket BHA - Attempt to recover retainer ring at the top of diverter tool.

The initial run was made with Venturi Junk Basket to retrieve accumulated debris at the top of diverter tool which may have prevented engaging to the diverter. 32.8ft above the diverter tool at (16,847ft) circulation with brine through CT was established upon tagging at 16,857ft. Several cleanout passes were performed across 16,821-16857ft, at varied pumping rates from 1.3 to 2 bpm, with subsequent slack offs at 16,857ft. As CT with Telemetry system was utilized during the job, actual annulus / tool differential pressures were monitored during the job. As per zoomed in Fig. 8, we clearly see differential pressure between tool and annulus pressures at varied pumping rates. Afterwards, pumping was stopped and CT was run in hole dry tagging at 16,857ft, string was flagged and CT was POOH to the surface. On Fig. 9 we can see recovered debris with VJB.

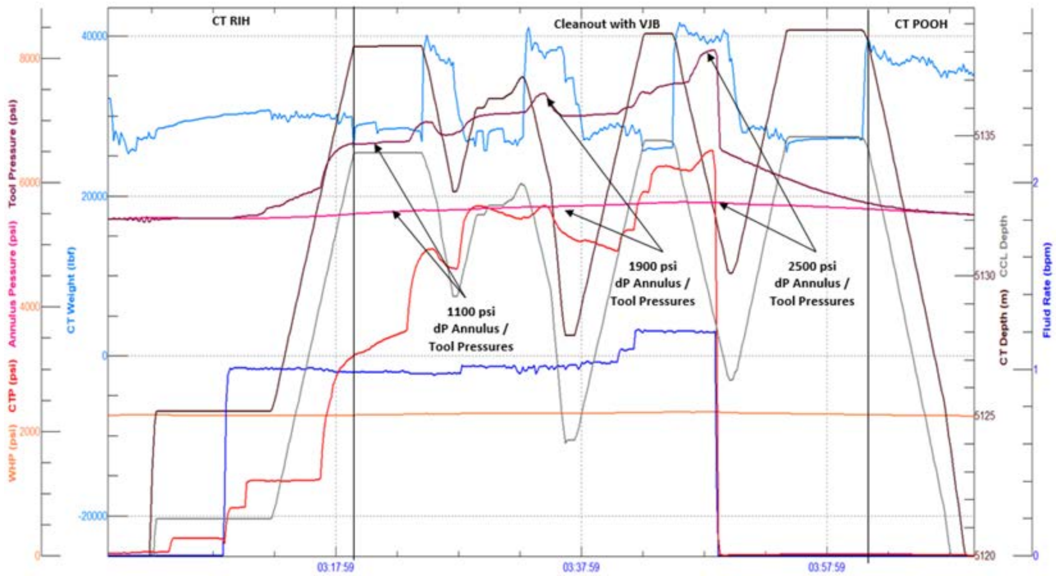

Figure 8—Run 1. Zoomed in Cleanout passes with VJB

Figure 9—Recovered Debris from VJB

Run 2. Vortex BHA - Jetting & spotting acid on top of the diverter tool

Next Telemetry CT run continued with acid wash at the top of the diverter tool. The purpose of the Vortex BHA was to jet / swirl and spot acid via tangential offset of its jet orifice from the tool centerline on top of Diverter tool to remove any debris and or sediments from the top section and ease latching to retrieving tool. CT was run in hole to 16,876.6ft (16,847ft Diverter Tool in MB) and stopped there, as no slack off was observed. Having CT parked at 16,876.6ft, 15% HCl acid was spotted and 30 mins soaking time was applied with subsequent CT POOH to the surface upon elapsing of soaking time.

Run 3. Fishing BHA – Attempt to retrieve diverter tool

Run 3 commenced with fishing BHA to retrieve diverter tool. 32.8ft above diverter tool (16,824ft) pull test was performed indicating about 0.78 klbf of pick-up weight on TCT. Afterwards, TCT reading was set to zero to ensure accuracy of downhole compression and tension data. CT continued to run in hole until slacking off at 16,865.8ft -3.1 klbf at the bottom as per TCT. Further, TC was slowly picked up to 16,858.9ft and stopped having 2 klbf in TCT tension. In few minutes, TCT tension increased to 2.2 klbf without applied CT movement, indicating about 0.2 klbf of additional jarring up. Further, when CT commenced picking up 16,856.6ft sudden loss in TCT sensor from 2.4 klbf to 0.14 klbf was recorded. Another few attempts were made with CT, tagging at the same depth 16865.8ft while slacking off at the bottom about -2.4 klbf and -2.3 klbf according to TCT readings and further latching about 1.8 klbf in tension afterwards slipping off to 0.4-0.5 klbf. As no indication of engagement to the fish was recorded, as per Fig. 10, CT was pulled up to the surface, no diverter tool was retrieved. Upon SL performed run with LIB, it was indicated that parted section of ITTCR was left at the top of the diverter tool from previous attempts of WSO in lateral bore (Fig. 11 LIB result with ITTCR).

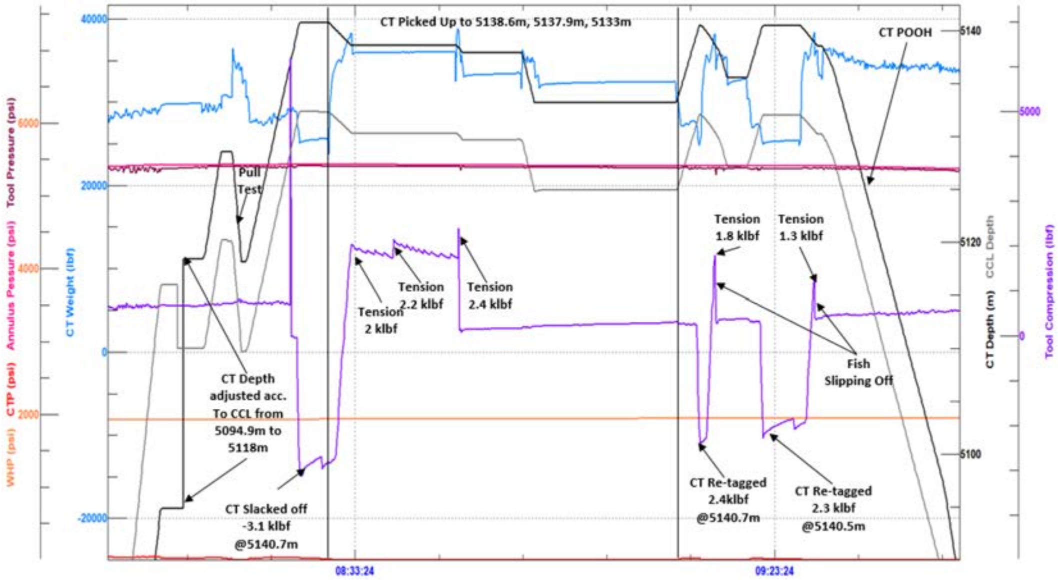

Figure 10—Run 3. Zoomed in attempt to retrieve diverter

Figure 11—Run 3. LIB result & parted ITTCR retrieved in run 4, removed from overshot at shop

Run 4: Fishing BHA – Recovery of ITTCR section

As the result from SL run with LIB, coiled tubing was run in hole with different fishing BHA to recover ITTCR section. CT was run in hole to 16,820.8ft pull tests with / without circulation were performed and weights had been recorded. Further, TCT compression reading was zeroed to ensure preciseness of downhole monitored axial forces if diverter tool was recovered. CT resumed to run in hole while circulating diesel at 0.5 bpm until slacking off at 16,867.8ft downhole -3.1 klbf as per TCT readings. CT re-tagged (-3.2 klbf TCT) at 16,868.1ft while continuously circulating diesel at 0.5 bpm. Pumping was stopped, CT repeated run ins and pick-ups, first reaching to 16,869.4ft slacking off -3.3 klbf and further tagging higher at 16,868.1ft. Further, jar fired up from -2,9 klbf to -4 klbf and dropped to 0.48 klbf in tension. Those additional 0.12 klbf in tension had indicated that fish was latched, and CT was pulled up to the surface. ITTCR (Fig. 13 ITTCR recovered during run 4) was successfully recovered from the wellbore.

According to the Fig. 12, we can see how much weight downhole we slacked off and compare with software simulation predicted results, as well as we can observe from the surface, efficiency of jarring downhole and how much additional slack off weigh was gained.

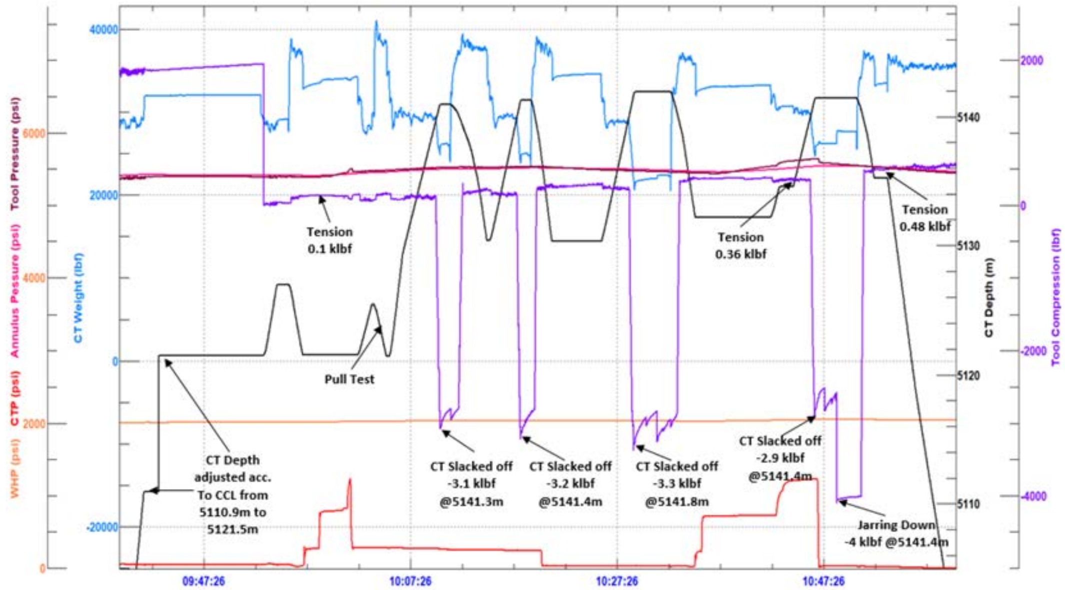

Figure 12—Run 4. Zoomed in fishing ITTCR

Figure 13—Run 4. ITTCR recovered

Figure 14—Simulation of how it is believed the parted ITTCR was located above diverter

Changing the plot to depth base data as opposed to time based data, provides alternative view to evaluate CT pick up weight and Tool Tension prior and after latching to the fish. Fig. 15 focuses on elapsed time and compares CT weights from third and fourth passes, where CT surface weight up (average 36 klbf) didn't change as we latched the fish due to insignificant weight of the ITTCR section, however, we did observe additional 0.12 klbf gain in TCT tension which clearly indicated that we were able to catch the fish. Without presence of TCT confirming even negligible fluctuations in tension, fishing operation would be more challenging

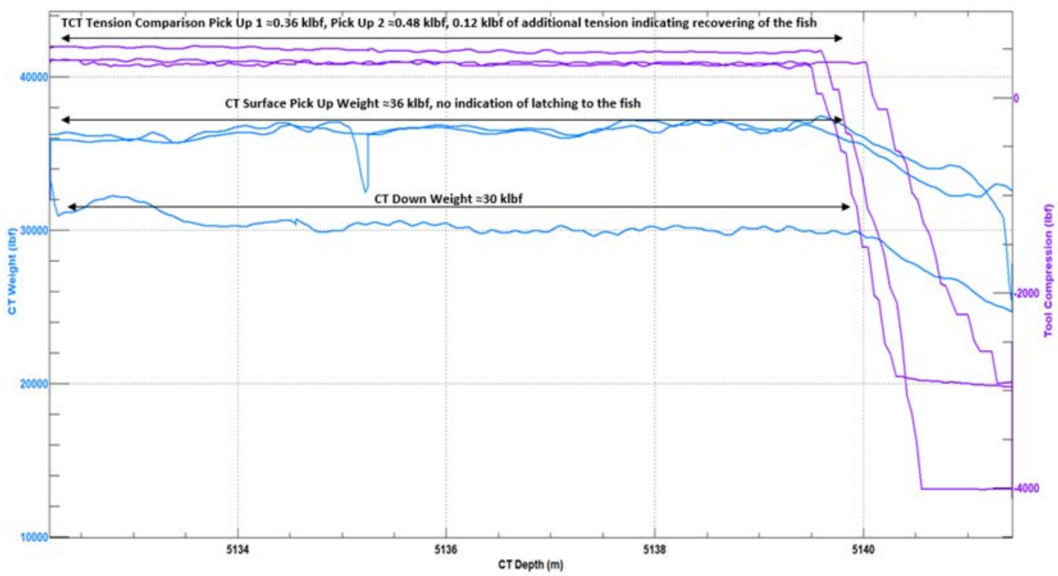

Figure 15—Run 4. Zoom in Fishing ITTCR. CT Weight Comparison & TCT Tension vs CT Depth

Further data yields a comparison from third pass between actual weight on bit (Fig. 16) that we had according to TCT readings and software simulation results (Fig. 17). It shows that applied weight predicted by software simulation to gain required WOB matches with recorded downhole load from the operation. There was no requirement to slack off maximum weight on bit during the fishing operation, thence acquired downhole data was compared until jar activation. As an outcome, due to alignment of software predicted values with actual downhole readings confirms reliability and accuracy of simulation software.

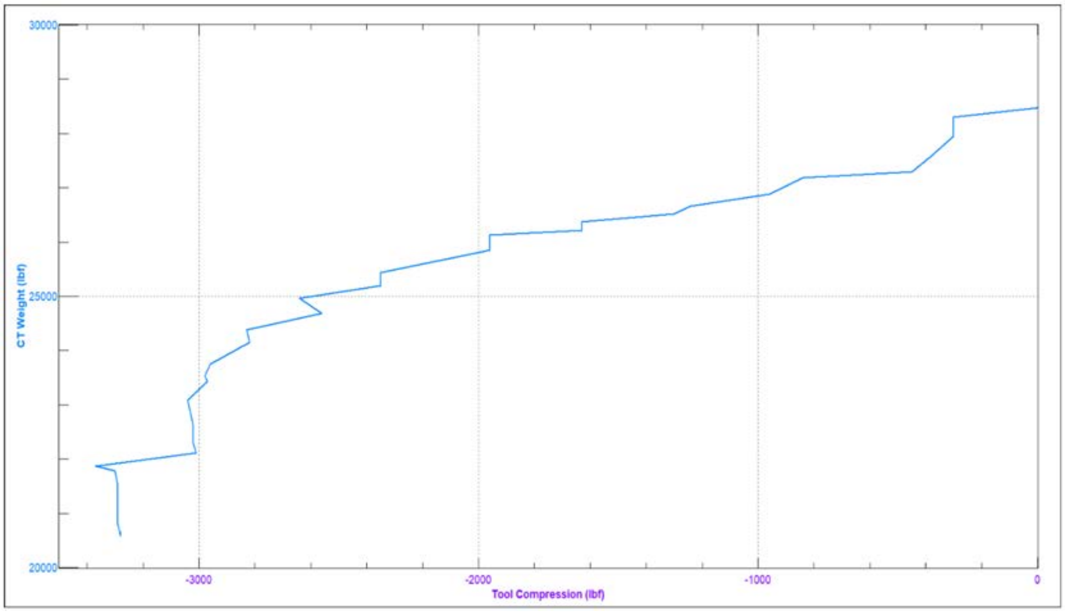

Figure 16—Run 4. Zoom In Fishing ITTCR. CT Weight Comparison vs

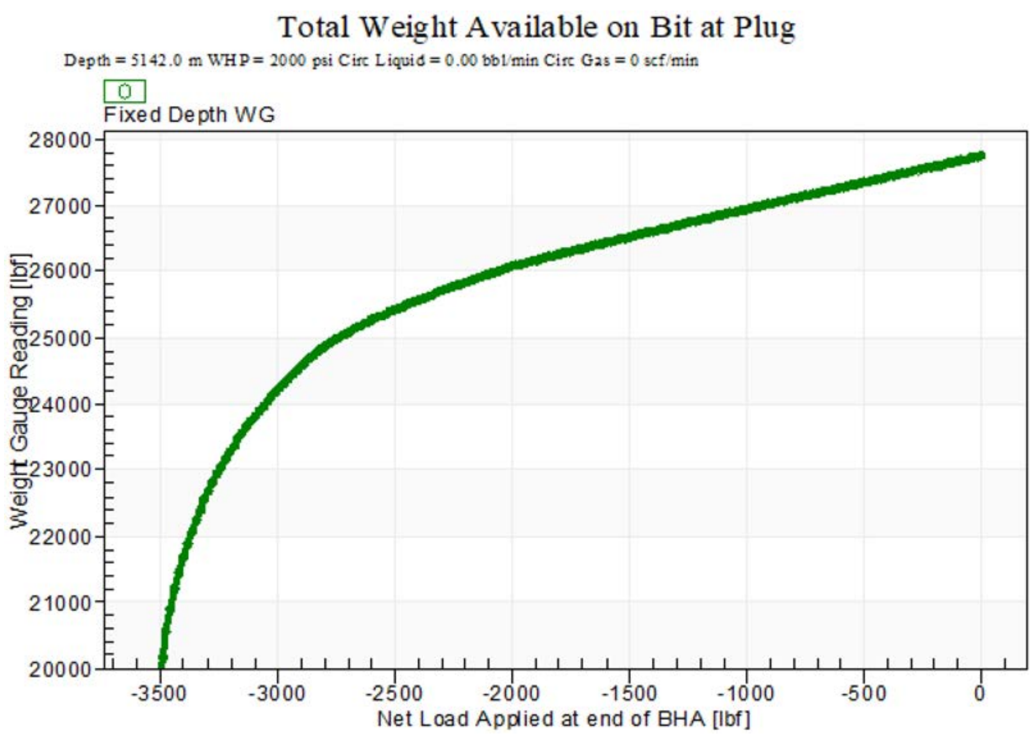

Figure 17—Run 4. Software Simulation Predicted WOB

Run 5: Fishing BHA - To retrieve diverter tool

Fishing BHA was RIH to 16,797.9ft, string was picked up 32.8ft and filled with diesel at 0.5 bpm with subsequent weight check ups. CT resumed run in hole without circulation until slacking off at 16,869.1ft (-4.1 klbf TCT). In few minutes TCT compression spiked down from -4.1 to -5 klbf indicating activation of jar down. Further, CT was slowly picked up to 16,859.6ft and parked there while TCT tension increased to 2.1 lbf. CT continued to move up and TCT tension increased to 4.3 klbf and further to 5.8 klbf with CT at 16,854.6ft. In 2 mins TCT tension rapidly dropped to 0.3 klbf. CT was run in hole and tagged at 16,866.5ft slacking off -3.5 klbf downhole and pulled up with no indication of fish latching. As the result, diverter tool was not retrieved. During fishing BHA inspection, broken slip of modified overshot (Fig. 18) was observed which prevented successful outcome of the job. Decision was made perform next run with PDM and Washover BHA to cleanout mechanically setting area of the diverter tool thereby making following fishing attempt easier.

Figure 18—Run 5 broken slip from overshot

Run 6: Washover BHA – Cleanout of diverter tool setting area

At this point it was decided to run a washover BHA Fig. 19 with DH motor in order to have a rotation movement of the modified overshot pulling tool to try to clean the setting surface of diverter tool. The objective was to try to make it easier for the following fishing attempt. CT was run in hole to 16,830.7ft, pull test with diesel circulation was performed. First slack off for -0.85 klbf downhole with diesel circulation at 0.5 bpm was observed at 16,864.5ft. Once 5 bbls of HCl acid was spotted above the diverter tool and soaking time was applied, CT was picked up / down 1.6ft at the top of the diverter tool while circulating brine at varied pumping rates 0.7-1.1 bpm to wash over the top of the diverter tool. Upon pumping was stopped CT commenced to POOH to the surface.

Figure 19—Run 6 Washover BHA before and after

Run 7: Fishing BHA – To retrieve diverter tool

CT commenced to run in hole with fishing BHA, at 16,790ft, TCT sensor reading was reset to 0 lbf and pull test with / without circulation was performed prior to latching to the diverter tool. CT was run in hole until slacking off at 16,871ft -4.1 klbf at downhole and picked up 9.8ft. Another CT penetration until slacking off at 16,873.3ft, first to -4 klbs further weight down stabilized to -3,5 klbf and jarred down to -4 klbf (-0.46 klbf of additional slack off weight down according to TCT). CT was picked up in steps, first to 16,859.9ft (2.4 klbf TCT tension) than to 16858.3ft (3.3 klbf TCT tension) and 16,856.9ft (4.2 klbf TCT tension). In few minutes, jarring up for additional 0.84 klbf tension in TCT was recorded and instant tension drop to 0.1 klbf afterwards, confirming release of diverter tool. During CT POOH to the surface overpull at 16,842.5ft

(LEN) was observed. The average TCT tension while CT POOH from 16,820.9-16,804.4ft was 0.23 klbf indicating that diverter tool was latched and being recovering to the surface. Stripper was tagged, PCE broke down and diverter tool was successfully retrieved to the surface from wellbore. Fig. 21

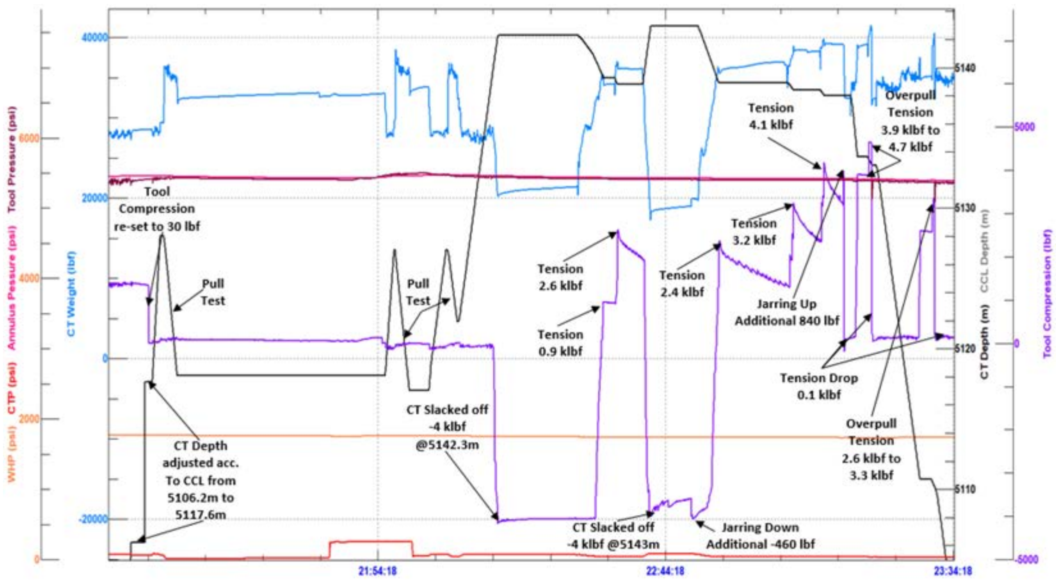

Figure 20—Run 7. Zoom in Fishing Diverter

Figure 21—Run 7 Diverter Retrieval & comparison with part of ITTCR on

The plot as per Fig. 22 was extrapolated on CT weight and Tool compression curves according to CT Depth interval 16,797.9- 16,879.9ft. During the pull test CT Pick Up weight was 36.8 klbf and after the first pass coil weight up was almost the same 36.9 klbf, however TCT tension had increased to 2.6 klbf indicating engagement to the fish. Thus downhole observations are solid advantages which enhances performance of fishing operations with TCT sensor.

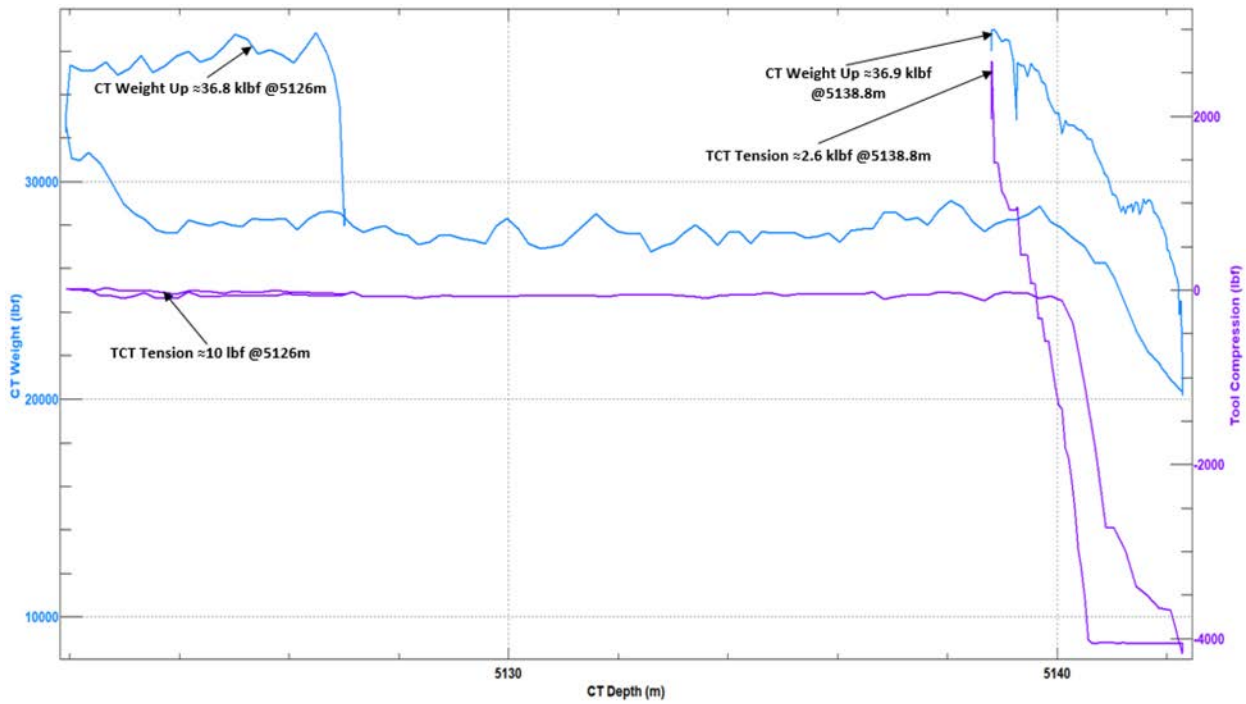

Figure 22—Run 7. CT Weight Comparison & TCT Tension vs CT

Furthermore, comparison of load tension prior to latching the fish and after 2 passes Fig 23, shows additional 0.23 klbf in tension, -0.08 klbf of initial TCT reading and 0.15 klbf gained tension after jarring up.

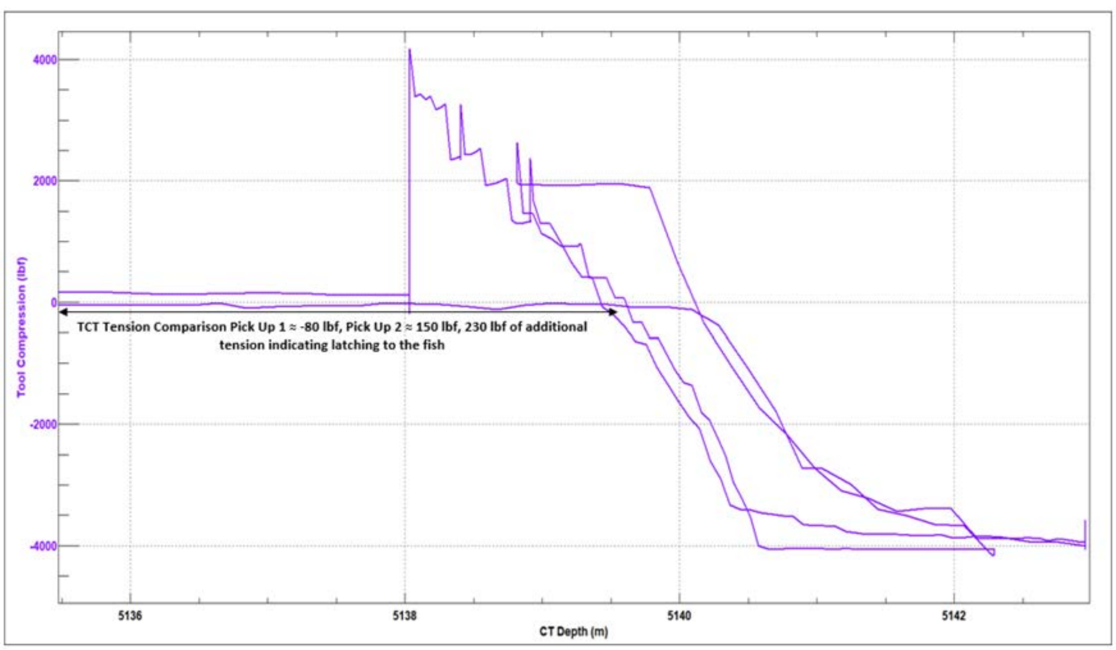

Figure 23—Run 7. Tool Tension vs CT Depth

In addition, another evidence of reliability and accuracy of simulation software was confirmed during seventh run while fishing diverter. Comparing most important variables such as surface load with downhole tool compression Fig. 24 parameters recorded from the first pass down until first slack off, we clearly can see that predicted WOB Fig. 25 matches with actual ones acquired from the job.

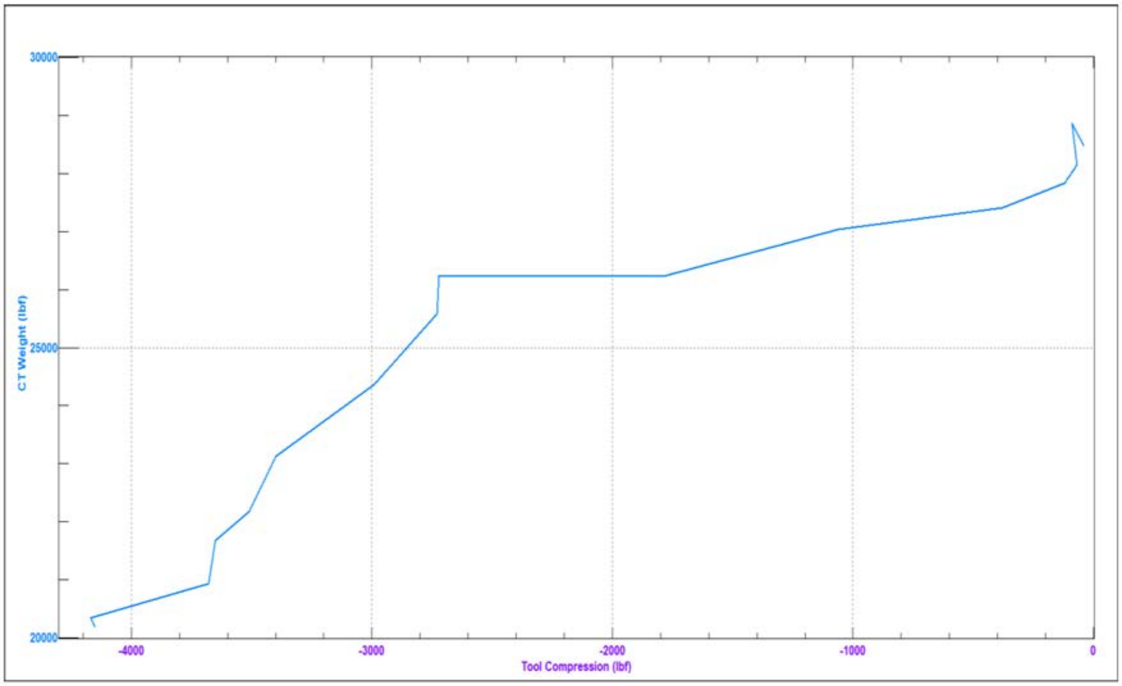

Figure 24—Run 7. Zoom in Fishing Diverter. CT Weight Comparison vs TCT Tension

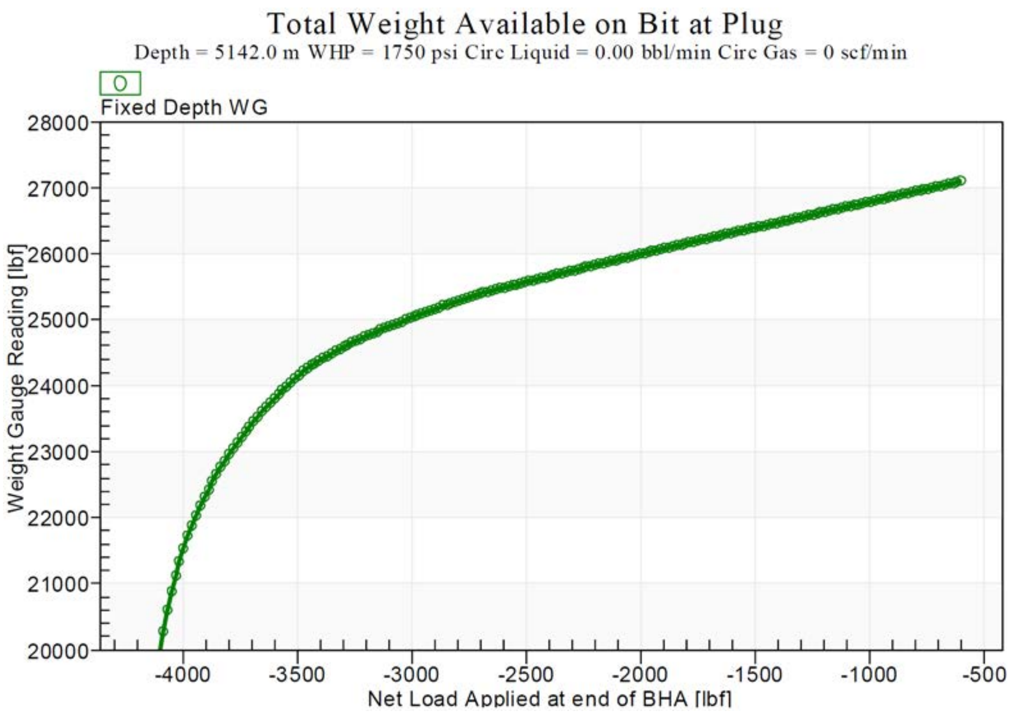

Figure 25—Run 7. Zoom in Fishing Diverter. CT Weight Comparison vs

Run 8: Venturi Junk Basket BHA to recover debris from top of prong

During a slickline operation done inside 4 ½″ × 3 ½″ completion, below diverter tool setting depth (16,848.1ft) in order to check condition of top prong that was set at Baker 2.562″ Baker model ‘HOF’ no-go nipple @16,958.7ft, sediments presence was determined there. Based on this VJB run was recommended before running fishing BHA for prong retrieval. Fig. 26 Recovered debris This run was performed without CT telemetry system as 2-1/8″ TCT and IS were not available in the country, thereby CT performed run without telemetry system at the BHA. VJB BHA commenced RIH until slacking off at 16,919.3ft while tagging top of prong. String was flagged and in total 3 cleanout cycles at 1 bpm were performed. Further, CT was POOH at the surface and some debris accumulation was retrieved from VJB.

Figure 26—Run 8 Recovered debris

Run 9: Fishing BHA to retrieve prong

CT was run in hole to 16,797.9ft MD another 32.8ft pull test was executed with and without circulation through coil. CT resumed to run in hole first slacking off at 16,824.1ft, 16,830.7ft and 16,853.7ft trying to run in hole deeper referring to flagged pipe from the previous run with VJB. Finally, CT penetrated until slacking off at 16,935.7ft. CT successfully recovered prong to the surface.

Afterwards, slickline had failed attempt to recover plug to the surface and final run with CT fishing BHA was initiated to retrieve the plug.

Run 10: Fishing BHA to retrieve plug

CT was run in hole until 16,830.7ft MD and pull test with and without circulation was performed for 32.8ft. Slacking off at 16,911.1ft coil was picked up with overpull observed at 16,902.9ft. In several attempts to pick up, coil released from the overpull and continued pull up until tagging stripper at the surface. Plug was successfully retrieved during the run.

Conclusion

The ease with which we were able to adapt to unforeseen circumstances saved resources to customer. The use of CT was selected after multiple comparisons done with wireline, as another option for retrieval of diverter, prong and plug; by running fishing tools with tractors and stroker devices (due deviation 50 degrees). The previous unsuccessful attempts to retrieve the diverter and the shut-in conditions with positive wellhead pressure in sour environment made this an ideal scenario to proof the versatility of the application of intelligent coiled tubing. Depth control played a critical role in this operations and having realtime correlated depth was a defining factor for the cleanout and fishing runs.

- For the first time worldwide 2 7/8″ TCT sensor telemetry system was applied in fishing/retrieval operations. Despite all factors which had complicated indication of diverter tool latching, such as light diverter tool weight of only 90 lbs, well trajectory and buoyancy effect, TCT sensor could detect latching to the diverter tool on fishing BHA as additional 0.13 klbf tension reading during CT POOH.
- During CT POOH after latching to the diverter tool while CT was passing through wellbore restrictions the coil speed was adjusted according to TCT downhole real time readings that prevented any potential overpulls and subsequent job complications.

- Acquired downhole axial forces (tension and compression) from the job helped to confirm reliability and accuracy of simulation software by alignment of software predicted variables with actual downhole readings.
- Operator certainty in performed operations with software simulation predicted results increased and gained more confidence.
- It was another proven case history of an effective alternative option of prong & plug retrieval in challenging wellbore conditions.
- Based on performed scope of work, running in hole with VJB and/or Washover BHA with motor prior to fishing attempts have proved themselves as a good practice to be implemented for future jobs, especially one that have been shut down for some period.
- The use of CT proved to be a superior option of retrieval / fishing operations compared to the use of Slickline or Wireline with tractor and stroking devices.

Acknowledgements

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Nomenclature

BHA	: Bottomhole Assembly
CCL	: Casing Collar Locator
CT	: Coiled Tubing
CTT	: Coiled Tubing Telemetry
DP	: Differential Pressure
FT	: Feet
IN	: Inch
IS	: Integrated Sensor
ITTCR	: Inflatable Through Tubing Cement Retainer
KLBF	: Thousand Pound-Force
LEN	: Lateral Entry Nipple
LB	: Lateral Bore
MB	: Main Bore
MD	: Measured Depth
MPLT	: Memory Production Logging Tool
POOH	: Pull Out Of Hole
RIH	: Run In Hole
SIWHP	: Shut-in Wellhead Pressure
TCT	: Tension, Compression, Torque
VJB	: Venturi Junk Basket
WHP	: Wellhead Pressure
WSO	: Water Shut Off

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Appendix A

TCT Subassembly Specifications

Dimension and Ratings	Sensor Capabilities		
OD	2.875”	Axial Load Range	-10,000 to 56,000 lbf
Make-up Length	6.26 ft (91.9m)	Axial Load Resolution	<20 lbf
Max. External Pressure	9000 psi	Axial Measurement Error	<5%
Max. Temperature	300 ^{0}C	Torque Range	1500 ft-lbf
Max. Differential Pressure	5000 psi	Torque Resolution	<20 fr-lbf
Max. Flow Rate	8 bpm	Torque Error Margin	<2%

Appendix B

Run 7. Hydraulic Spear Modified Overshot Pulling Tool

No.	DEPTH	LENGTH	OD	ID	DESCRIPTION
1		0.30	2-7/8"	1.00"	FM Grapple connector, 2.13-8" SA pin
	0.30				
		2.00	2-7/8"	0.56"	IS MHA, 2.13-8" SA box x 2-3/8" PAC pin
	2.30				
2		0.3	2-3/4"	0.98"	Cross over, 2-3/8" PAC box x 1-1/2" AM MT pin
	2.60				
3		2.29	2-1/8"	0.73"	CT Jar Intensifier, 1-1/2" AM MT box x pin
	4.89				
4		1.48	2-1/8"	0.90"	Weight Bar, 1-1/2" AM MT box x pin
	6.37				
5		1.96	2-1/8"	0.74"	CT Jar, 1-1/2" AM MT box x pin
	8.33				
6		0.38	2-1/8"	0.44"	UHD, 1-1/2" AM MT box x pin
	8.71				
7		0.23	3.10"	0.80"	Crossover, 1-1/2" AM MT box x 2-3/8" Reg pin
	8.94				
8		0.52	3.00"	0.31"	3.5" GS Hydraulic Spear, 2-3/8" Reg box
	9.46				
9		0.79	3.58"	1.00"	Modified Overshot Pulling Tool
					3.5" GS Internal fishing neck
	10.25				*No external fishing neck*
					Ports present at body
	10.25				**Total Length of BHA**
#10	**11.26**				**Total Length of BHA after FB Diverter Retrieval**