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Optimized Well Performance With Electric Line Interventions

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Abstract

In recent years, re-invention and development of electrical wireline mechanical applications, initially for high-angle well-access in conjunction with wireline tractors, has proven able to unlock value potentials by allowing interventions, previously thought impossible or cost prohibitive, even in low angle wells. Common denominators are remote-control, rig-less operations and documented large value-creations.

The most recent advancement in this service category includes milling and drilling on wireline; a breakthrough within intelligent production optimization. With the ability to engage a wide variety of challenges downhole, this technology provides hitherto unseen possibilities to increase production quickly, efficiently and safely. Also representing new capabilities is the technology of transforming constant mechanical force independently of the wireline and depth/deviation of the well. The advantage here is that operations can be performed from a crane or mast unit with electric line and apply a pulling/pushing force capable of manipulating down hole production control devices in a controlled and repeatable manner.

This paper will present innovative areas of recovering production through various case histories.

Introduction/Background

With today's high operating cost it is important to identify areas where new technology can be used to reduce rig time and improve production efficiency. Mechanical interventions such as manipulating valves and sliding side door devices, setting/retrieving mechanical plugs and gas lift valve retrieval/deployment, has historically been the domain of Slick Line techniques in vertical wells and Coiled Tubing in horizontal wells. These methods are difficult to execute in the intelligent completion environment because of the complexity in passing downhole jewelry without consequences such as damaging or shifing the sleeve devices unintentionally. With the introduction of the Well Stroker **(Figure 1)**, in conjunction with the Well Tractor **(Figure 2),** to the Gulf of Mexico, North Sea and West Africa markets, there has been a marked reduction in time and costs for operators carrying out mechanical interventions with standard electric wireline in intelligent completions whether in high or low hole angle holes. As tractor technology evolved and confidence was gained during the past several years, another application of electric wireline methods was developed and field proven; this time for milling of specific downhole hardware (i.e. valves, plugs etc.) as an alternative to existing methods (rig/CT). This technology is specifically needed on offshore installations where the logistical limitations for this kind of operation are high.

Figure 1. Well Stroker

Figure 2. Well Tractor

Many deep-water completions use downhole isolation valves for temporarily closing off production while awaiting first oil or flowline connections. These valves can be shifted open or closed through surface command, pressure pulse signals in the fluid column which activates stored nitrogen pressure in the body of the valve housing. These isolation systems are available from several major suppliers but all have a less than perfect track record of shifting on command. To be prepared for the occasional failure of the pressure command to shift the valve, a contingency is provided to have electric wireline tractor technology with options for either a stroking tool to mechanically shift the valves or a milling tool which will cut a machine precision hole in the valve. There are other new devices that are also available, which contribute to improving the success of these operations.

Equipment Description

The Well Stroker was the first remote controlled mechanical intervention tool developed for the intelligent completion. When the stroker tool is activated, it hydraulically anchors itself against the ID of the tubing or casing and can then exert a pushing or pulling force of up to 16 tons in either direction. The energy that is created by the tool can be utilized to mechanically shift sleeves open or closed, set and retrieve down hole plugs without the use of any explosive devices – enhancing safety or retrieve and replace downhole artificial lift devices like GLV and Jet Pumps. The stroking tool is either tractor conveyed in high angles or run in with only the shifting tool attached in low angles. A new intelligent shifting tool, called a Well Key **(Figure 3)** is also available that opens and closes customized "keys" on command to avoid hang-ups that can occur with the conventional spring loaded shifting tools. This combination solution is faster to mobilize, more precise and reliable to execute and less expensive than the alternative coil tubing solution.

Figure 3 The Well Key tool

The Well Miller is often a seconday contingency in a valve failure situation but may become the primary contingency if there are no future plans to use a downhole valve device. The milling tool is also effective at removing barium sulfate scale, cement or composite bridge plugs and is designed to be used with the tractor. The tractor provides the weight-on-bit and the torque control which (as with drill pipe and especially with electric line) is critical in any milling operation. The milling tool consists of an electronics section, hydraulic compensator, electrical motor, gear box and the bit. The tool sizes are 3 1/8" and 2 ½" and can operate in completions with a minimum ID above 2.7". The tool string length **(Figure 4)** deployed on conventional wireline is approximately 8 meters long and weighs 250 kgs depending on the configuration.

Figure 4. Well Miller & Well Tractor

Another electrical wireline mechanical service for interventions is the Well Cleaner **(Figure 5)**. It offers the ability to selectively clean areas of the wellbore of scale

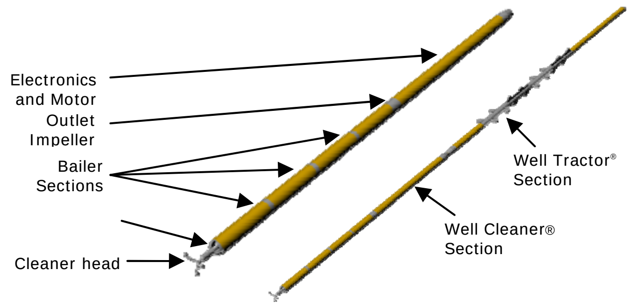

Figure 5. Well Cleaner and Well Tractor

bridges and sand fill without having to mobilize coiled tubing. There are two cleaning systems; one for liquid and one for dry environments. Working in a liquid environment, the cleaner tool uses vacuum flow as the main force in the bailing of sand. In a dry environment an auger system is used to carry the sand fill up into the bailers. The tool consists of a basic rotational unit (BRU) that includes electronics, pressure compensator and electric motor sections. The BRU drives an impeller which creates the vacuum flow to circulate through the liquid environment tool 'dragging' sand into the 0.5" intake holes where it will deposit in the sand trap bailers. Depending on the configuration of the tool, a different number of bailer sections can be mounted.

Case Histories

1. Isolation Valve Contingencies

A North Sea operator was considering the options for remedial action in case a 5.5 inch diameter downhole isolation valve, which was at a depth of 10,916ft, should fail to open. Normally, coiled tubing would have been the first contingency but due to the platform derrick design, which has a low A-Frame, an electric wireline conveyed shifting tool was selected as the preferred method in the the event the valve failed to open. The liquid environment cleaning tool, Well Cleaner LE, was also chosen to be on standby to address the possibility of debris cleanup if the shifting tool could not latch due to debris fill on top of the valve.

Execution of the Contingency:

To re-establish connectivity to the reservoir, several attempts were made to cycle the isolation valve with surface applied pressure pulses, as per procedure, but surface pressure indications showed that the valve would not function. The Well Stroker with the valve specific mechanical shifting tool attached, was rigged up with a Casing Collar Locator for depth control on top and run in hole (RIH). Based on friction/drag modeling, a tractor would not be required to reach the isolation valve with a deviation of 64º, because gravity alone should provide enough force. However, the tractor was also run to save time in case it was needed to overcome higher friction forces than expected. The tool string sat down hard approximately 48 ft above the isolation valve indicating 48ft of fill on top of the valve. It was confirmed that an unprecedented amount of dolomite and barite solids would have to be removed and it was calculated that approximately 20 wireline runs with the Well Cleaner would be required to clean out to regain access down to the valve. An agitator cleaning head was selected as the best choice for removing this type of debris **(Figure 6a).**

Figure 6a & 6b. Liquid environment cleaner before RIH (left) and debris chamber (bailer) filled with sand after cleaning (right).

The tractor-cleaner-bailing system was RIH to first “tag” the top of the fill and the “pick-up” depth was determined for reference on the clean-out progress. The tool-string was then powered up to begin the cleaning operation with the tractor configured to provide a reduced speed to slowly drive the cleaner while controlling the reactive torque from the rotating cleaner head. The first three cleaning runs were configured conservatively with five debris chambers (bailers) and a capacity to hold 8.5 litres of solids. Two of these three runs returned to surface with all chambers full, one run returned with half the chambers filled. The debris is removed and the chambers are reused on subsequent runs **(Figure 6b).**

With increasing confidence in the safe pull-out-of-hole weights from the first three runs, eight chambers were configured in the tool string for the next six cleaner runs equating to a capacity of 13.6 litres. All runs returned to surface with chambers filled. Depth indications determined one more run could reach the valve and the final run was conducted with five chambers and returned to surface with all chambers filled. A total of 11 successful cleaning runs were carried out removing 92.5 litres (485 lbs) of solids. Less runs were required than expected due to bridging of the scale and fill.

At this point, with the obstruction removed, another attempt was made to cycle the valve open with surface applied pressure pulses but this was not successful.

The first contingency of using the stroking tool with mechanical shifting tool was again rigged up and RIH but this time without the tractor as it was not needed on the first RIH. A clear path to the isolation valve depth was observed and the shifting operations commenced. Though it took two attempts before the shifting tool would latch in the shifting sleeve (probably made difficult by some remaining debris in the area of the sleeve), the isolation valve was opened successfully.

Results:

- Use of electric line conveyed cleaning system with no HSE issues and minimized downtime, enabled the valve opening contingency to be successful.

- The well production was more than expected following the cleanout and valve opening.

- Reduction in offshore personnel and heavy equipment handling, reduced cost by an estimated 1/5th of the alternative, CT option, which was not a viable option given the type of platform and derrick.

- Benefits from lessons learned in eliminating heavy lift requirements for CT, by using tractor and associated technology, are transferable to other areas globally.

2. A Combination of Milling Tool & Dry Environment Cleaner for Scale Remediation:

A North Sea operator was losing production on a dry gas well faster than normal decay. Camera investigations had shown Barium Sulphate scale bridges in the tailpipe **(Figure 7).**

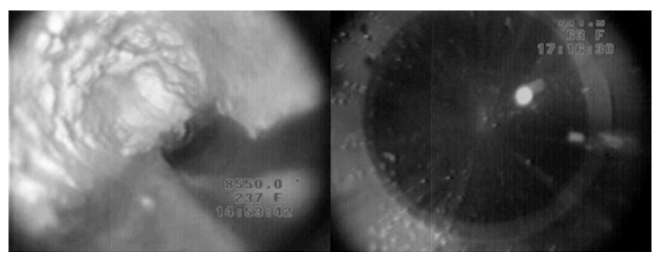

Figure 7. Down Hole Video pictures of Barium Sulphate scale in tubing and a clean section of the same tubing.

Coiled Tubing was the conventional method of removing scale. The operator challenged this option and explored the alternative of deploying a milling system on electric wireline. The well bores were almost completely blocked by scale but the length of these bridges was estimated to be at most 10 – 12 ft, a short distance which would be feasible for electric line milling. The operator worked closely with the service provider to confirm mill design & size along with the requirements to protect the cable from damage during milling. Extensive testing completed before mobilisation to field, led to 2 mill bit sizes being chosen. A 3.8 inch mill was run first to open up through the scale, while remaining within the torque envelope of the tractor system. Then a 4.2 inch mill was run to give the required final ID. Deployment of this electric line milling system, allowed a July work window ahead of the original CT time frame of September, whilst minimising impact on the platform maximum Personnel On Board constraint of 40.

Following the successful wireline tractor milling of scale above the perforated interval, it was found that 2/3rds of the 69 ft of perforated interval (in 5.5 inch liner) was obstructed by sand and scale fill. Normally, slick line bailing would be the best option in this situation because of cost and with the well at a low inclination angle of 39 degrees, it would usually be effective. However, slick line bailing was attempted but not successful due to the heavy Barium Sulphate scale debris. Coiled Tubing was the next conventional option but had significant mobilization costs. An E-line solution was preferred and pursued. The liquid environment cleaning system with its rotating head and vacuum system would not be effective in a dry gas environment. Therefore, a different solution would have to be created.

The solution was the cleaner system for dry environments (described above), which was a modification to the milling and liquid environment cleaning system already in existence. Surface testing of this new technique was required to demonstrate it to be effective at removing dry fill. To accomplish this test, a tubing was filled with 51 litres of sand and laid out horizontally. The cleaning system was configured with 6 long bailer sections, each with a capacity of 5 litres. The cleaner was driven into the tubing with a tractor and cleaning commenced making two passes. When the tools were retrieved and the chambers emptied (**Figure 8**), they contained a total of 50 litres of sand indicating that the cleaner system had an efficiency of approximately 98% in a horizontal pipe and therefore, could expect an efficiency of 90 - 95% in a lower angle of say, 39 degrees.

Figure 8. Dry environment cleaner with paddle head and auger (left) used in surface tests. Bailer section filled with sand (right).

After thorough pre-job planning, specific procedures were written for the unique application in this dry gas well which incorporated a practice phase for the wireline engineers to control the speed of feeding the cable into the well.

Job Execution:

During the first cleaning attempt, the maximum penetration into sand fill and scale debris was 5ft. Because of risks associated with sticking the tool string, it was brought out of the hole to get a better tool for the job. The electric line milling tool plus tractor were then rigged up and RIH to where a scale bridge had reformed. Scale milling commenced and the bridge was milled out to an ID of 4.2” in 25 minutes with a total operational time from rig up to rig down of 10hrs 50min.

Next, the dry environment cleaner plus tractor were rigged up and run in hole to the top of the sand fill at 9,845ft with a deviation of 39º, a pick-up weight (tension check) was taken and the tools were energised to begin cleaning operations. When the debris subs were filled the tools were pulled out of hole. A visual inspection verified the debris sections were completely full **(Figure 9).** Four cleaning runs were made and each one was successful. Total downhole cleaning time was approximately 5 hrs with total operating time from first rig up to final rig down was 51.5 hrs.

Figure 9. Bailer section filled with Barium Sulphate scale and sand fill from Case History 2.

Data and Results:

- First use of new auger cleaning technology with no HSE issues and no unproductive time.
- Removed 80 litres of sand and scale
- Delivered incremental production of +3 mmscf/day
- £0.5MM savings on operations costs compared against traditional methods.
- Reduction in total offshore time (14 days vs 35 days for CT)
- Reduction in people offshore (crew of 15 vs. 35 for CT)
- HSE benefit of eliminating heavy lift requirements for CT
- Technology transferable to other areas globally

Conclusions:

Mechanical services on electric wireline now provide well interventions for the removal of scale, clean-out of debris/fill and shifting of valves without mobilizing coiled tubing. These services create large value from reduced costs, improved production, quicker mobilizations and with less risks, especially in the offshore environment.

The combined focused effort from the operator and service company can provide a fast-track development of step change technology as in the North Sea case histories.

Electric line milling and cleaning are effective alternatives for small cleanout jobs and only requires a Well Tractor and a specific miller/cleaner for the type of debris and environment.

Acknowledgements

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NOTE: Welltec carries a registered trademark upon its conveyance and mechanical service devices referred to herein.

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