# Coiled Tubing "Vacuum" Restores North Slope Wells

The North Slope of Alaska is home to thousands of oil wells, most drilled horizontally and then stimulated with hydraulic fracturing or allowed to flow through natural formation fractures. Wellbore plugging caused by proppant flowback and formation fines can be a problem in these wells, with severe impact on production.

For most of these wells, conventional coiled-tubing (CT) cleanouts are possible, using nitrogen to lift the cleaning fluid and suspended proppant to surface. Some of these wells, however, are so underpressured that normal CT cleanouts are technically and/or economically unfeasible because of the massive amounts of nitrogen required to achieve returns to the surface.

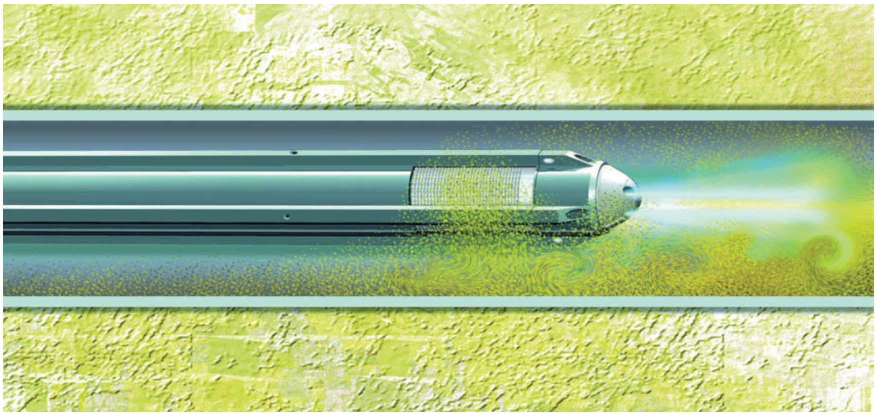

***Fig. 1—A downhole vacuum tool draws in wellbore fluids. The concentric coiled tubing provides a flow path for the return pressure, making the use of nitrogen unnecessary.***

## A Vacuum Cleanout Method

One alternative is to clean out the fill by means of concentric coiled tubing (CCT) with a downhole-vacuum tool. The BJ Services Sand-Vac cleanout tool is based on a jet pump comprising a high-pressure nozzle, suction port, and diffuser **(Fig. 1).** High-pressure fluid is accelerated through the nozzle, creating a pressure drop that essentially draws in wellbore fluids, jetted fluids, and suspended solids. A diffuser allows the velocity of the combined flow to decrease and the pressure to increase. This pressure gain is sufficient to drive the column of return fluids back to the surface.

To run the jet pump, power fluid is pumped down the center of a CCT string, with a portion of the fluid allowed to exit an external nozzle to fluidize wellbore solids. Returns come up the larger annulus between the inner and outer strings. Because the CCT string provides the additional flow path, the wellbore is not exposed to the return pressure and, therefore, nitrogen is not required. All of the supplied fluid is returned to the surface, leaving none in the well.

This technology was born in the Canadian heavy-oil fields, and it has been proved in a decade of cleanouts around the world—especially in low-pressure, horizontal wells and in areas where nitrogen logistics are difficult or simply too expensive to justify.

## Alaska Gas Wells

In 2006, for example, this technology was employed on the Tyonek platform in the Cook Inlet basin in southern Alaska (Rafferty et al. 2007). This platform ties together 14 wells that produce from the Cook Inlet and Beluga reservoirs, which have bottomhole-pressure (BHP) gradients of less than 0.1 psi/ft.

Both reservoirs are composed of highly permeable, friable sandstones that tend to slump into unconsolidated sand piles upon exposure to water. Water breakthrough, therefore, creates major sand-production problems for wells in this area.

Four wells were identified as viable fill-cleanout candidates for which traditional CT cleanout methods had proved excessively expensive or technically futile. A rigorous engineering and simulation process determined that the job should use a 9,600-ft CCT string of 2-in.-outer-diameter tubing with 1-in. tubing inside. The engineering plan also called for 6% potassium chloride mixed with a liquid-concentrate friction reducer, pumped at an average rate of 0.5 bbl/min at 4,800-psi injection pressure. Fluid losses were monitored studiously and the jet-pump tool switched from sand-vacuum (solids fluidization and intake) to well-vacuum (intake of wellbore fluid only) mode to ensure that at least a 1:1 ratio of pumped to returned fluid was maintained.

The technology successfully removed more than 36,000 lbm of solids from the four wells in 10 days of operation time, including tripping time to depth. BHP and temperature gauges, run below the vacuum tool on two wells, recorded notable increases in pressure and temperature where fill was removed from previously covered production intervals.

Further opportunities for greater efficiency were identified during these operations. For example, some of the sand bridges encountered proved very difficult to wash through with the vacuum tool. Therefore, during winter 2006–07, engineers at BJ Services' Coiled Tubing Research and Engineering Center (CTRE) in Calgary modified the vacuum-tool design to improve its forward-jetting capability for compacted fill.

## North Slope Application

In July 2007, the new tool and a record length (14,529 ft) of 2×1-in. CCT


***Fig. 2—Deployment of the coiled-tubing vacuum-cleanout tool in the Kuparuk River basin of Alaska's North Slope during summer 2007 enabled the removal of 88,900 lbm of fill from 21 wellbores.***

arrived in the Kuparuk River basin of the North Slope to clean out proppant flowback in a collection of low-pressured oil wells that conventional CT technology had been unable to clear **(Fig. 2)**.

In addition to the problem of low reservoir pressure, the wells in the basin's Kuparuk field are S-shaped, directional wells that typically come off a single pad location, extend through a 50 to 60° deviation, and then dip back to 20° through the production zone.

In the neighboring West Sak field, the wells are extended-reach horizontals with measured depths of up to 15,000 ft and true vertical depths of only 3,800 ft.

These factors demanded careful analysis with proprietary CT-job simulation software to ensure safe operating parameters and efficient performance. In some cases, the CCT was unable to reach total depth of these tortuous wellbores safely, but the cleanouts typically cleared at least 80% of each well's key production intervals. Additionally, the software's lockup predictions were typically within 2% of actual depth achieved.

In all, CT crews deployed the modified vacuum tool over more than 250,000 running feet in 21 wellbores, cleaning out approximately 88,900 lbm of fill and proppant. Cleaning each well took an average of 3 days, including rig up/down, pressure testing, and tripping.

Operational challenges began almost immediately, as the first well was discovered to contain proppant as large as 10 mesh, whereas the tool's sand-intake screen was designed to accommodate only up to 20/40 proppant. A spare tool was sent to CTRE for modification while CT crews in Alaska proceeded to clean out other wells known to have been fracture stimulated with smaller-mesh proppant.

The modified tool was returned to the field within 3 weeks and was able to successfully clean out the wells containing the larger proppant sizes.

## Three Case Histories

In one typical Kuparuk-field well, wireline confirmed the top of fill at 10,931 ft. The CT crew used the downhole vacuum tool with seawater, pumped at 0.5 bbl/min down the 1-in. inner CT string, returning 15,225 lbm of proppant and formation fines up the 2×1-in. annulus. Time required on bottom to wash sand was 16 hours.

A post-job wireline tag indicated that all fill was removed to the well's total depth of 11,205 ft.

In a typical West Sak well, the formation is naturally fractured, so the fill is composed of formation fines. As noted earlier, these wells are extremely deviated, meaning that wireline was unable to confirm the top of fill. As a result, the vacuum tool was actuated upon reaching 7,000 ft and was deployed in hole until reaching a maximum achievable depth of 10,182 ft. This compared favorably with the model's prediction of 10,170 ft. Average penetration through the horizontal section was 2.5 ft/min, requiring a total of 33 hours to remove more than 9,000 lbm of formation fines from the wellbore.

The new forward-jetting assembly also was used extensively in the Kuparuk field. Of the 21 wellbores cleaned out, the high-pressure, switchable jetting assembly was used in 16 of them. The jetting switch is actuated from surface by decreasing the pump rate, waiting for stabilized pressure, and then increasing the pump rate. The tool can be switched from vacuum mode to jetting mode as often as necessary. Without this advancement, multiple CT runs would have been required in order to penetrate through consolidated-fill regions.

To illustrate this, one of the last wells of the project proved successful because of the ability to switch to a high-pressure jetting mode. The top of fill was confirmed by slickline measurement at 7,583 ft. During the cleanout, a consolidated sand bridge was encountered at 7,598 ft, stopping forward movement of the CCT in vacuum mode. After switching to forward-jetting mode, the bridge was broken easily. The tool was switched back to vacuum mode so that the cleanout could continue. The well was cleaned out to 7,691 ft, recovering 4,200 lbm of proppant.

Looking to the future use of this CT cleanout technology in Alaska, additional campaigns are undergoing detailed logistical and engineering planning.

*Information provided by Jason Skufca, Coiled Tubing Technical Manager, BJ Services.*

## Reference

Rafferty, P., Ennis, J., Skufca, J., and Craig, S. 2007. Enhanced Solids Removal Techniques from Ultralow-Pressure Wells Using Concentric-Coiled-Tubing Vacuum Technology. Paper SPE 107010 presented at the SPE/ICoTA Coiled Tubing and Well Intervention Conference and Exhibition, 20–21 March, The Woodlands, Texas, USA.

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