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CONCENTRIC COILED TUBING AND SPECIALS TOOLS HELP TO INCREASE THE PRODUCTION IN ORINOCO BELT

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Abstract

In this paper we describe the excellent results obtained with Concentric Coiled Tubing (CCT) Technology in two new campaigns in the Orinoco Belt with two different operators. Horizontal wells in unconsolidated sands, with very low pore pressure, are very difficult to clean and stimulate with conventional methods, as they are not effective to remove sand, filter cake, and remaining drilling fluids out of these wells. The CCT is combined with special tools such as Vacuum Tool, Sand Cleaning tool and Rotational Jetting Tools to yield the desired results. CCT jobs have been done in both horizontal new and old wells, completed with slotted liner / open hole. Due the lost circulation problems during drilling, damage is created, and needs to be removed. In new wells, acid stimulation is being used successfully. In old wells, solvent treatments with Rotational Jets and conventional sand removal operations are being done in order to improve their performance and production. We intend to illustrate the methodology applied on the campaigns, the results and usefulness for the CCT, combined with different tools, in a heavy oil, high crude viscosity, unconsolidated and low pressure reservoir.

Introduction

PDVSA, S.A., Petróleos de Venezuela, S.A, is the Venezuelan state corporation in charge of exploration, production, transporting and marketing hydrocarbons. PDVSA San Tomé is part of the South District on the Eastern zone of the country. It is made up of the Bare, Melones, Leona, West Lejos and Arecuna fields.

The most predominant characteristics of the wells in this area, are the following:

- Heavy and extra-heavy crude
- Shallow wells (3,500 – 4,000 feet - vertical depth)
- Horizontal Wells (7,500 feet average MD and 2,500 feet average TVD)

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- Low pressure zones or unconsolidated sands
- Bottom hole pressure average of 1,000 psi
- Bottomhole temperature average 130°F
- Oil gravity (8 – 10) °API
- Porosity between 30 – 35%
- Average permeability 1,000 mD
- Average crude viscosity @ 120°F between (3,000 – 5,000) cp

SINCOR, Sincrudos de Oriente, is a strategic association between companies such as: Total (France), PDVSA (Venezuela) and Statoil (Norway), to last a 35 year period, starting its first production in 2001. The main objective of this operator is to transform extra-heavy crude from the Orinoco belt into light oil with 32°API. The production activity is developed in the south of Anzoategui state, in San Diego de Cabrutica where Campo and the Main Station are, and in Pariaguán, where the administrative offices are.

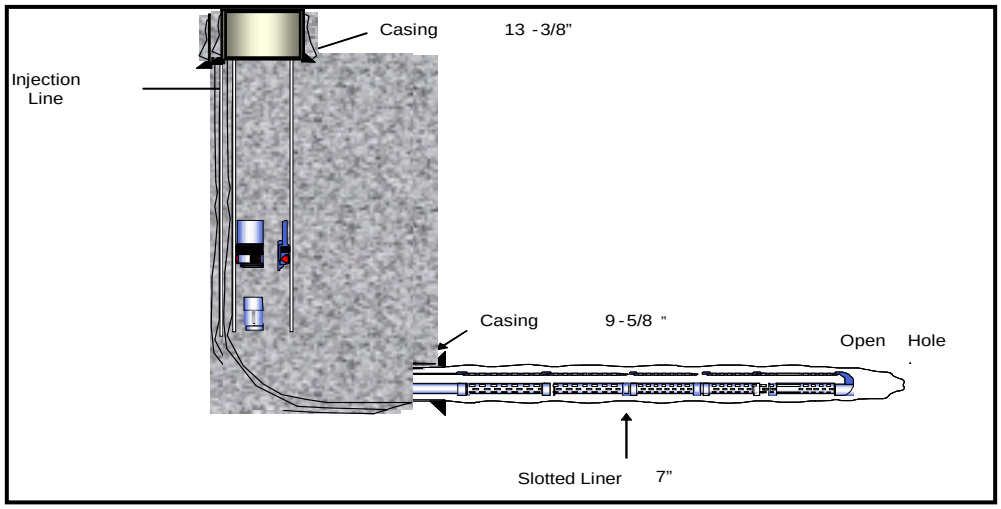
The most predominant characteristics of the SINCOR wells are the following:

- Heavy and extra-heavy crude
- Horizontal Wells (7,500 feet average MD and 2,500 feet average TVD)
- Low pressure zones or unconsolidated sands
- Bottomhole pressure average of 650 psi
- Bottomhole temperature average 120°F
- Oil gravity (8 – 10) °API
- Average porosity 30%
- Average Oil viscosity @ 120°F 2,500 cp

Well Details

The production wells in the Orinoco belt, both in Sincor as in PDVSA San Tomé are horizontal. These wells are completed with progressive cavity pumps and electro-submergible pumps, as well as production line and a line of diluents injection to the bottom to reduce the viscosity of the oil, which makes transport easier. The design of each well generally has a 13-3/8" surface casing, a 9-5/8" intermediate casing and a 7" slotted liner (Open Hole), used to extract the fluids from the well. The slotted liner can vary in its dimensions, depending on field conditions.

Figure 1 General wells Schematic.



After studying and analyzing the reasons for the decrease in production in several wells at the Zuata field (SINCOR), simulations done in 6 wells drilled 4 years ago lead to apply the special tools technology along with the Concentric Coiled Tubing technology, to increase well production.

Additionally, along with PDVSA San Tomé personnel, recently drilled wells were chosen from the Bare field, to apply the Concentric Coiled Tubing technology and special tools technology.

Well Problems:

The reservoirs in the Orinoco belt are reservoirs of heavy and extra-heavy oil with high viscosity, and are also non-consolidated sands, which means that the solids production is common, accumulating at the heel of the horizontal section. The location of the solids in this section causes a production decrease of the well. It is important to note that the reservoirs have low pore pressure.

During drilling of most horizontals wells, the weight of the hydrostatic column of drilling fluid creates loss of fluids in the formation. After drilling is complete, the liner is run in the hole and hung in the production casing. During the procedure of liner installation, the well is full of drilling mud, filter cake in place. Removal of filter cake could impact well integrity, and reduce the chances of successfully placing the liner at the bottom of the well. Even when the drilling mud and the filter cake do not result in permanent damage to the formation, this will affect the transmissibility of the reservoir, as an artificial barrier is now present between the face of the formation and the exterior of the liner.

Another common problem in the Zuata field wells (SINCOR) is the creation of a fine layer of oil, deposited around the slotted liners, causing blockage, and resulting in reduction of production.

Technology Used:

During the work process, and in order to increase the production in the chosen wells, the Concentric Coiled Tubing (CCT) technology and the Vacuum tool were used.

CCT is made up of two strings, an internal one of 1.25”, through which the power fluid is pumped and an external tube of 2.375”, through which the recovered fluids from the well return. Along with the CCT, right on the end, the vacuum tool is installed. This tool has two modes, a sand removal, and recovery mode, and a fluids recovery mode.

When set for Sand recovery, the tool run with CCT is used to remove sand, or formation evaluation in horizontal wells. This tool allows to continually return sand to the surface without the need for nitrogen in wells with low pressure formations (of up to 150 psi) and where it is common to lose circulation with traditional methods (using low-density fluids). Water is pumped through the inner tubing to remove sand and create the suction effect in the tool, and almost all fluid pumped returns with collected sand to surface by the annulus formed by the two Coiled Tubing (internal and external). A back jet system allows the tool to operate effectively while it is being pulling out of hole (POOH), ensuring that all the sand is removed.

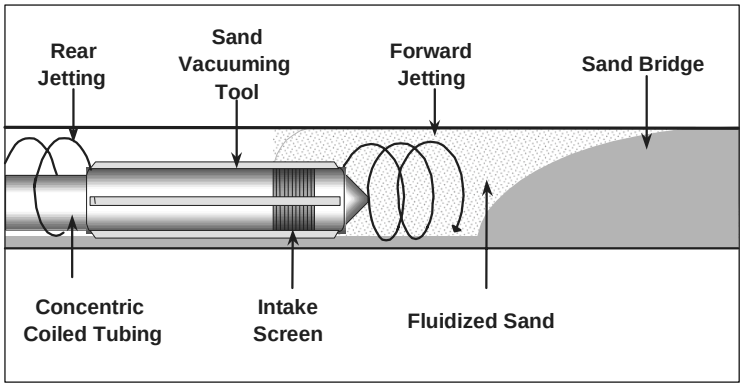


Figure 2 Sand Removal and Solids Recovery Mode

Once solids removal is finished, the pump rate is adjusted to create the maximum drawdown and place the tool in the fluids recovery mode. At this mode, the jets are deactivated, and all the power fluid (water or diesel) goes through

the internal ports of the tool, creating a bigger drawdown (previously mentioned), and recuperating this way large quantities of fluids from the well.

The Vacuum tool can be used with other systems such as:

- Specific enzymes that can be circulated in the well to remove the filter cake left by the drill-in fluids.
- Memory Gauge tool.

This tool is currently available in 2-1/2" and 2-1/8" diameter.

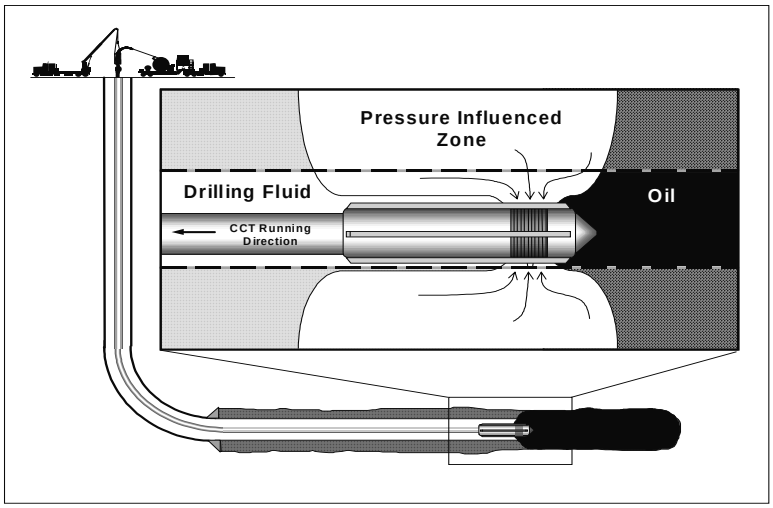


Figure 3 Fluids Recovery Mode

In order to dissolve the thin layer of oil created around the slotted liner, which blocks the flow of fluids coming from the well, it is necessary to run a special stress-cycling jetting in the wells able to dissolve this oil layer, and also allows pumping solvents through it. This is why, after the necessary simulations, a special Rotary Jetting tool (RJT) with stress-cycling performance was run in the wells. The RJT is currently one of the most effective scale and removal tools in the industry. The stress-cycling jetting assures the removal of deposits in one run, which reduces the fatigue effects on Coiled Tubing. The stress-cycling, a result of controlled speed on the rotating jets, induce cyclical pressures on the well's deposits, helping to remove even hard scales. It is used to remove sand, scale, plaster, sulphur, mud, gel, asphaltenes, parafines, calcium carbonate and other materials. These cyclical stresses take place several times a second, pulverizing the fragile scale into very small particles which are easily transported to the surface. The RJT is also a highly effective and cost-effective method to stimulate wells. The high-powered jets of this tool can place acid into close contact with the formation through perforations, liners or gravel pack completions. This tool is currently available in 1-3/4", 2-1/8" and 2-7/8" diameters.

Figure 4 Rotary Jetting Tool

In recently drilled wells, on fields with no or little information on their reservoirs, it is very useful to run the vacuum tool with pressure and temperature memory tool (**Memory Gauge Tool),** prior to completing the well (running the progressive cavity pump and the submergible electro pump). This tool can be installed on the end of the vacuum

tool, so that the register (on a memory card) of pressure and temperature (P&T) is possible during work. After running it through the well, the data is downloaded and analyzed to verify the well data (pressure and temperature).

Work Procedure and Results:

In order to increase production in the eastern part of the country, especially in the Southern district, belonging to PDVSA San Tomé, new fields have been explored. One of them is West Lejos, with unknown and uncertain reservoir data. A new well was chosen, LG-501, to perform a stimulation job with HCl, remove the damage, and apply the CCT technology, with vacuum tool, along with a Memory Gauge Tool, to record pressure and temperature.

The rehabilitation work done in said well was discussed between PDVSA San Tomé personnel, and BJ Services to implement the following: 2-3/8" x 1-1/4" Concentric Coiled Tubing run, along with a 2-1/2" Vacuum tool, and a Memory Gauge Tool. This first run to the bottom of the well used the tool on Sand Recovery mode, to recover solids from the well and assure horizontal section clean up. After receiving clean returns at the surface, the tool was cycled, the CCT was pickled, and a matrix stimulation job carried out, using 5% HCl throughout the length of the horizontal section. The acid was pumped through both spaces (internal Coiled Tubing and annulus between the two coiled tubing.) After the stimulation, the pumps rates were adjusted, creating a bigger drawdown at the tool, and placed in the Fluids Recovery mode. In order to recover all pumped fluids and obtain high oil cut in the horizontal section, the CCT was cycled several times. Once the fluid recovery was done, the tubing was placed at the bottom of the well. The CCT was POOH (Pull Out of the Hole) with the tool in Fluids Recovery Mode, at a constant speed of 10 ft/min (3 m/min), until reaching the casing hanger, in order to register bottomhole flowing pressure and temperature from the well, at pseudo-stable conditions. The well was kept opened. After the tubing was placed on the casing hanger, the pumping was stopped, waiting for the well to reach static conditions. After the well is at static conditions, the CCT was run with no pumping, and with the well closed, at a constant speed of de 10 ft/min (3 m/min) until reaching bottom, recording the static pressure and temperature of the well. Finally, the CCT was POOH to surface, disconnected from the tool, and data downloaded for analysis. Results on 6 new wells treated as above described are observed in **Table 1.** With these results, an increment of more than 80% in production can be observed in comparison with wells not treated this way.

Well	BOPD After Stimulation and Vacuum Job
MBF- 696	727
MBF- 698	1.530
MBF- 699	880
LG- 501	385
MBF- 696	908
MBF- 696	810

Table 1 Production after Vacuuming Jobs in new wells (PDVSA)

After extracting the information from the Memory Gauge Tool (pressure, temperature and time), the corresponding analyses were made and the results on **Figure 5**.

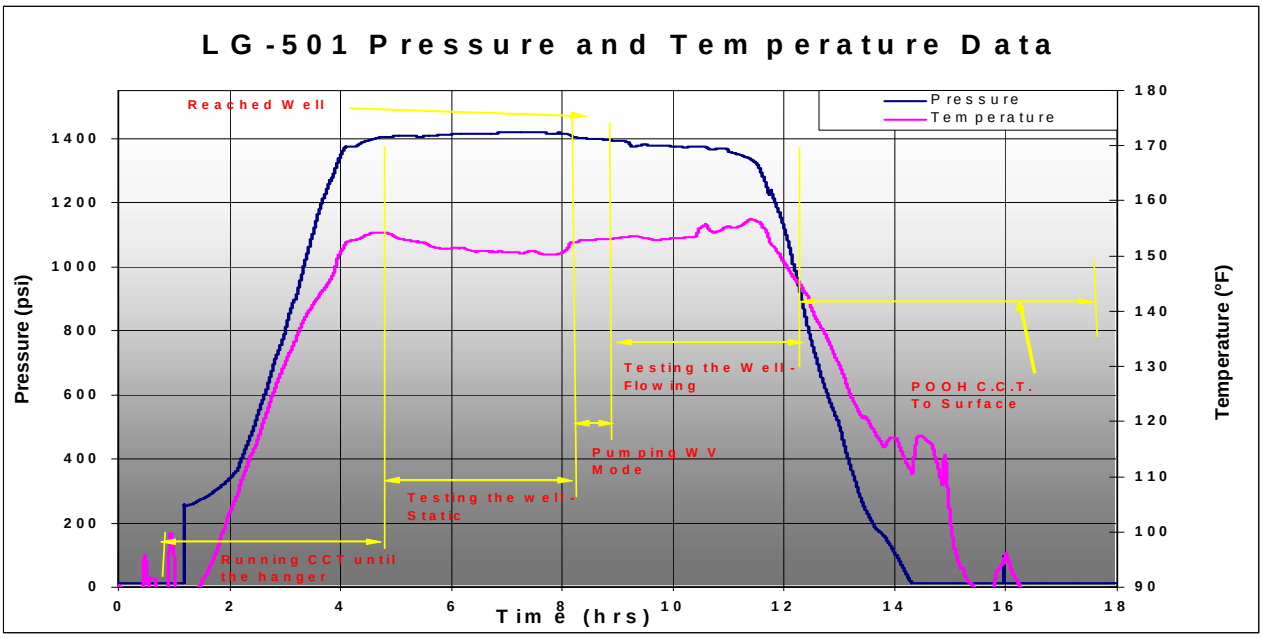


Figure 5 Pressure and temperature registered in well LG-501.

Along with the static pressures and temperatures illustrated in **Figure 6**, the flowing pressures and temperatures along the horizontal section can be also analyzed (**Figure 7**).

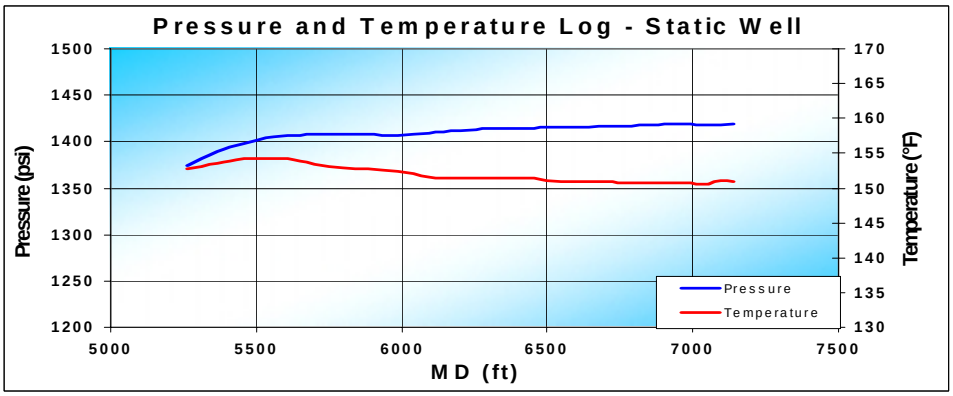


Figure 6 Register of Static Pressure and Temperature

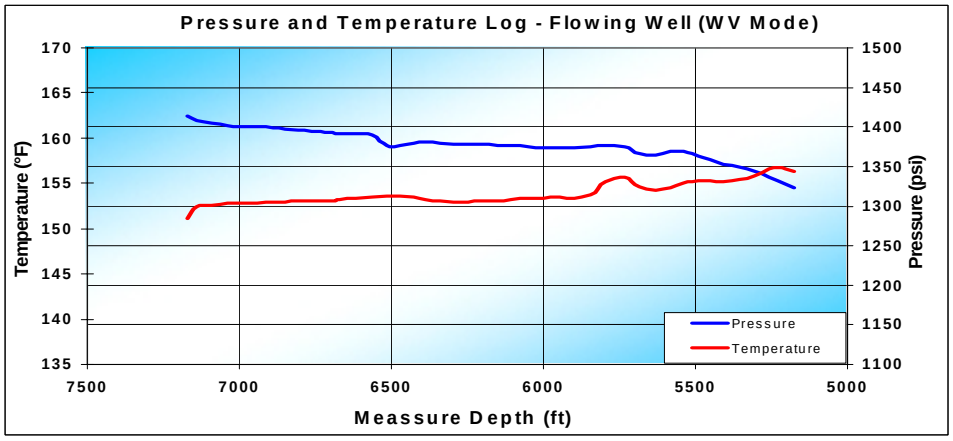


Figure 7 Register of Flowing Pressure and Temperature

After several pre-operational meetings, making the equipment adjustments, and work programs, it was decided to move the Concentric Coiled Tubing equipment as well as the additional equipment to the Zuata field (SINCOR). Once the regulatory permits were obtained, equipment checked, surface pressure checks made, operations began on three selected wells.

The procedure called to slowly run CCT in the well, pumping through the internal Coiled Tubing, taking returns through CCT annulus, until reaching the KOP. At this depth the tool is changed to Solids Recovery Mode. The descent proceeds at a speed determined, primarily, by the existing friction between the CCT and the completion of the well. During the descent, solids are recovered to surface, cleaning the horizontal section, and cycling of the CCT is done as many times as necessary. The tool reaches the final depth in Solids Recovery Mode, determined as per simulations made by BJ's proprietary coiled tubing software called CIRCA^{TM}, used to analyze forces applied to the CCT, well hydraulics, etc. Once the tool is at the bottom of the well, the well is circulated until all sand is removed. At the surface, samples are taken to have sieve analysis, and to make an indirect determination of the liner's mechanic state.

Once the Solids Removal is finished, the tool is POOH to surface, uninstalled, and the special stress-cycling jetting tool RJT is installed, in order to impact the slotted liner, and remove the thin layer of oil around it. Once the RJT installation is done, CCT is again run into the well, pumping diesel to the top of the slotted liner through both spaces: through the internal coiled tubing, and through the space between the two coils). At this depth, the fluid changes to a solvent mix, to remove the layer. After pumping the solvent mix, the tool is POOH to surface, and rigged down, allowing the start-up of the completion installation.

The procedure above presented was applied to 6 old wells in the Zuata field (SINCOR): LA-10, VD-20, SB-01, IC-10, RA-06 and VB-09. After stabilizing the production of these wells, production tests were done, with excellent results, as in **Table 2**.

Well	BOPD Before CCT Job	BOPD After CCT Job	BOPD Gained
LA-10	0	666	666
VD-20	146	565	419
SB-01	195	692	497
IC-10	178	183	05
RA-06	0	406	406
VB-09	0	415	415

Table 2 Production increase after the rehabilitation work (Sincor)

Conclusions and Recommendations:

- The introduction of new technologies into oil or gas fields, such as the stress-cycling jetting Rotary Jetting Tool, Memory Gauge Tool, along with the Concentric Coiled Tubing technology / vacuum tool in two modes, have resulted to increase the production for operators on the Orinoco belt, such as SINCOR and PDVSA San Tomé.

- The use of stress-cycling jetting has been deployed on horizontal wells, completed with slotted liners, in order to dissolve the thin layer of oil created around them, leading to increased production recovery.

- Due to the need of oil production increase in Venezuela, new fields have been explored without any knowledge about their reservoirs. Memory Gauge tools have been run in these fields in order to obtain data such as pressure and temperature, at both static and flowing conditions.

- Once a well is drilled, a matrix stimulation is necessary to remove' the filter cake created by the drilling fluids, followed by a vacuum tool run, on fluids recovery mode, on the horizontal section of the well to recovered all fluids (drilling fluids, stimulation fluids, oil and water).

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