



SAGD pilot project, wells MFB-772 (producer) / MFB-773 (injector), U1,3 MFB-53 Reservoir, Bare Field. Orinoco Oil Belt. Venezuela.

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Abstract

Petroleos de Venezuela SA, is pushing as one of its targets over the medium and long term to assess the feasibility of applying recovery technologies for heavy and extraheavy oil fields, this in order to increase the recovery factor of fields belonging to the Orinoco Oil Belt.

The SAGD process is a thermal recovery method applied in fields of heavy and extra heavy oil, where is generated in the reservoir the amount of thermal energy to reduce oil viscosity. Much of the success of the implementation of this process, in the Orinoco Oil Belt, is connected to the drilling and completion of the arrangement of wells at depths greater than 3000 feet, where the parallelism and spacing between them, cementing and completion design are critical.

To maintain the parallelism and spacing planned drilling SAGD pair, we used a magnetic guidance tool. In determining the appropriate thermal grout to use in cementing wells, laboratory assessments were performed on samples of different characteristics, and subsequently calculate the mechanical stress via a structural simulator.

The completion design SAGD pair, calculating the heat loss in the wellbore, so we used type injection pipe pre-insulated, thermal conductivity 0.007 BTU/hr-pie- ° F. To ensure the development of the steam chamber to inject steam down devices selectively, applying 70% of the rate of injection into the fund and 30% in the heel of the wellbore.

The methodology is presented as a spearhead to standardize operational procedures to be followed in the drilling and completion of future SAGD projects to be applied in the area of the Orinoco Oil Belt, where depths greater than 3000 feet, are a factor critical. With the development of the first pilot SAGD MMstb estimated 2 oil drain, increasing the

recovery factor of the area affected by the steam from 14% to 60%, leveraging the main objective of Orinoco Magna Reserva Socialist Project to increase the factor in the fields of the Orinoco oil belt through the application of secondary recovery processes.

Introduction

SAGD process, it is a thermal recovery method that involves drilling two horizontal wells, a producer located in the bottom of the reservoir and a steam injector placed in parallel to a few feet above the producing well. The steam forms a chamber whose heat is transferred mainly by conduction to the reservoir. Oil in the vicinity of the chamber is heated, reducing its viscosity and increasing mobility.

The SAGD process can be applied in fields that meet the following characteristics:

- Depth <6000 feet MD.
- Current pressure <800 psi.
- Low clay content.
- Permeability > 3 Darcys.
- Oil viscosity > 600 cps.
- Porosity > 28%.
- Net thickness > 60 feet.
- Reservoir without a layer of gas.
- Cut water <20%.

- Current oil saturation > 80%.

The first SAGD project in the Orinoco Oil Belt is applied on the Bare Field, specifically in the MFB-53 reservoir, sand U1, 3, which consists of unconsolidated sands rich in quartz, with variable amounts of detrital clay, these sand is of excellent reservoir quality with porosities exceeding 30% and permeabilities ranging up 7000 md. The net sand thickness in the reservoir varies between 60 to 100 feet.

From a structural standpoint, the reservoir is a monocline with a dip of approximately 3 ° North. Stratigraphically the MFB-53 reservoir is located in the Formation of Oligocene Merecure, beneath the surface unconformably on the igneous - metamorphic; overlying Formations Office Freites and Mesa-Las Piedras.

Listed below are the official data of the reservoir under study:

- Thickness (feet): 80
- Porosity (%): 28
- Permeability (darcy): 5
- ° API: 10
- Oil Viscosity (cPs): 684
- Reservoir Temperatura (° F): 137
- OOIP (MMBLS) = 5935.5
- Rec. Reser. (MMBLS) = 1127.749
- Rem. Reser. (MMBLS) = 846.6

STAGES OF THE PROJECT.

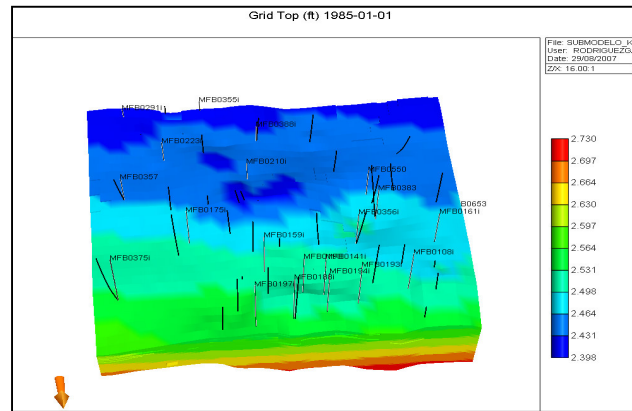
• Phase I “Planning”

This first phase of the project assessed the various critical factors prevailing during the application of any pilot SAGD, for this simulation models were conducted which evaluated important parameters such as the optimum rate of injection, the vertical spacing and the effective horizontal section. Also, it was determined the appropriate cement grout to prevent mechanical problems in the wells during the project.

The simulation model of the SAGD process main objective was to evaluate the implementation of SAGD process in the MFB-53 Reservoir Sandy U1, 3 analyzing the behavior of fluid production, recovery factors and steam-oil ratio.

The study was developed with a 3D Cartesian mesh 34x29x38 ft3. It was defined as two parallel horizontal wells, according to the definition of the SAGD process,

the steam injector on top and a producer at the bottom (Figure # 1).



drilling of wells (Figure # 3).

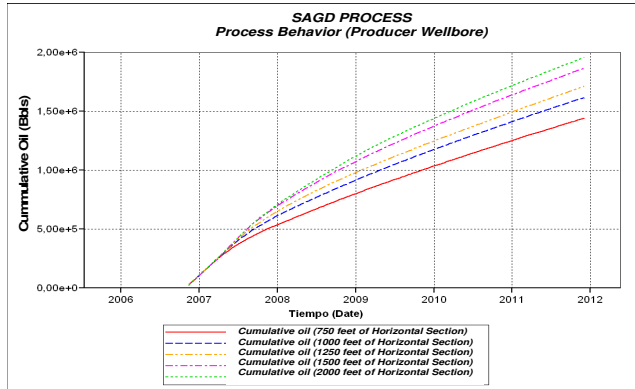
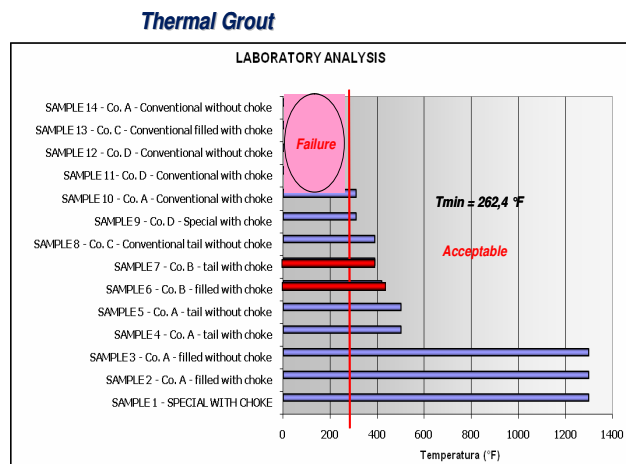


Figure #3. Cumulative Oil vs Time.

To determine the appropriate thermal grout to use in cementing wells, laboratory assessments were performed on samples of different features in a confined environment where we evaluated the mechanical properties of these, then processed the information obtained through a simulator structure, allowing to determine the capacity of the slurry to resist mechanical stresses generated during the life of the well, as the expansion and contraction of the casing could cause hydraulic fracture and communication (Figure # 4).



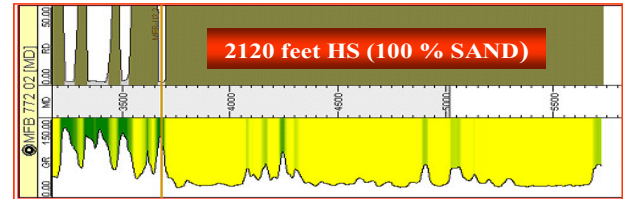
Figure#4. Evaluation of Thermal Grout results.

$$E = \frac{\sigma}{\epsilon} \quad (\text{Eqn. 1})$$

Where E is the modulus of elasticity, σ is the pressure exerted on the cross-sectional area of the object and ϵ is the strain at any point of the bar.

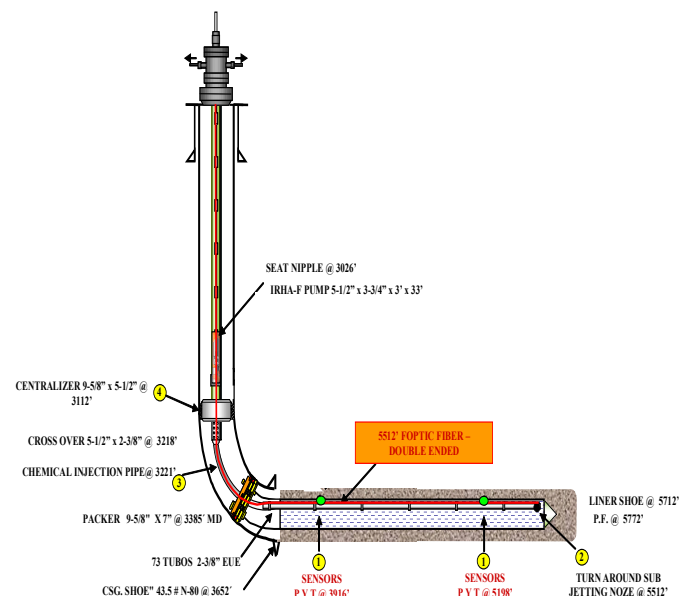
• Phase II “Drilling and Completion of the Producer Well”

In February 2008 it was started the implementation phase of the SAGD project by drilling of the well MFB-772, which was drilled using navigation tools (MWD-LWD). 5772 feet were drilled, with 2120 feet of horizontal section and 100% of net sand (Figure # 5).



Figure#5. GR- Resistivity log MFB772 well.

This well was completed with mechanical pumping equipment, using insertable pump (IRHA-F 5-1/2 "x 3-3/4" x 3 'x33'), with a lifting capacity of 3000 barrels of fluid. Through the application of SAGD are estimated to drain 2 MMstb, with an initial potential of 1500 STB/D. Pressure and temperature sensors as well as optical fiber were strapped to a tail pipe of 2-3/8 ", this in order to monitor the effect of injected steam along the horizontal section of the well. Similarly, a 3/8" capillar for chemical injection was installed at the bottom, with the risk of producing H2S due to the effect caused by the reaction between the sulfur in crude oil and hot water (figure # 6).



Figure#6. Completion Diagram MFB-772 well (producer).

- **Phase III “Drilling and Completion of the Injector Well”**

Subsequently it was drilled the well MFB-773. For the navigation of this well it was used a magnetic guidance tool (MGT), which helped positioning more accurately the injector, reducing errors in survey. This tool consists in the placement of a magnet installed transversely in a sub which is assembled in the BHA, just above the bit. When the bit turns and the drilling progresses, the magnetometers located in the producing well measure the variation of the magnetic field frequency versus depth. The tool is not affected by magnetic fields or tubular ground, thus minimizing the uncertainty in the trajectories of the wells (Fig. # 7 and 8). This well was drilled as planned, with a vertical spacing between wells of 34 feet. It were drilled 5778 feet with 1998 feet of horizontal section and 100% of net sand (Figure # 8).

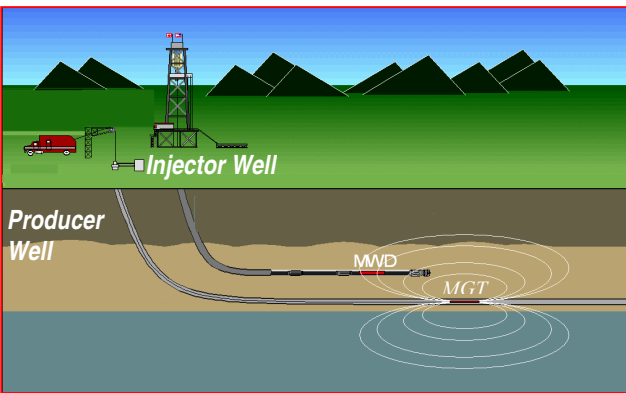


Figure # 7. Magnetic guidance tool for the drilling of the injector well.

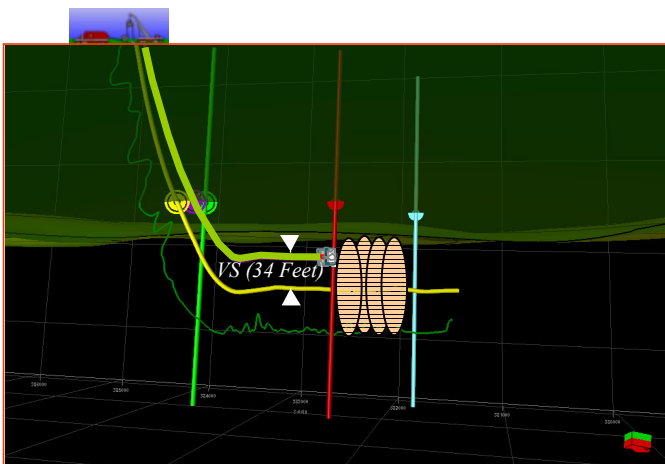


Figure # 8. Magnetic guidance tool (Vertical Spacing).

The MFB-773 (injector) was completed with pre-insulated pipe 4-1/2 "x 3-1/2", which has shown excellent results in reducing heat loss in the well, plus valves that will inject steam injection selectively (70% of the rate of steam at the end of the horizontal section and 30% in the heel). In this well were lowered pressure and temperature sensors in the horizontal section, strapped to the pre-insulated pipe, in order to monitor the conditions of steam in the reservoir (Fig. 9).

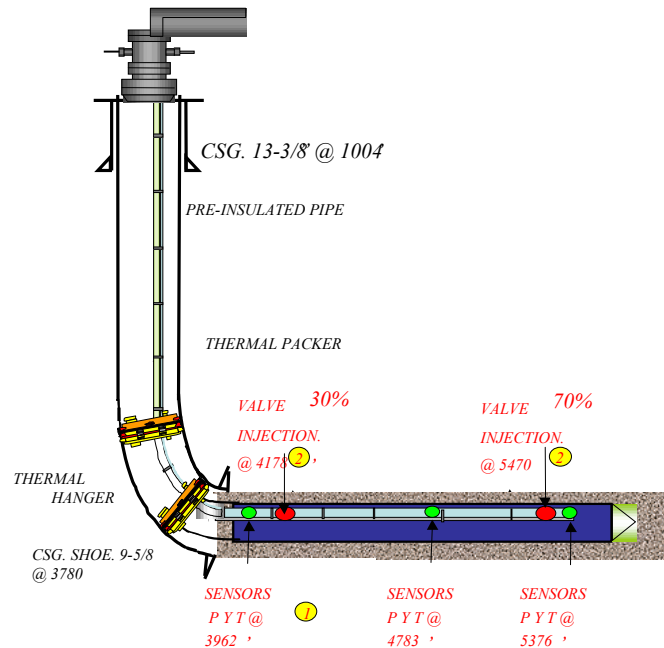


Figure # 9. Completion MFB-773 Injector Well.

- **Fase IV “Drilling and Completion of Observer Wells”**

In order to determine the behavior of heat in the reservoir, 3 wells were drilled vertical observers, MFB-685 (Observer # 1), MFB-784 (Observer # 2) and MFB-785 (Observer # 3) using a separation between them of 500 feet, this determined by numerical simulation. In the drilling of these wells were found sand thickness of 60 to 100 feet with excellent petrophysical characteristics (Fig. # 10 and 11).

At the completion of these wells were lowered thermocouple sensors and optical fiber, this in order to determine the behavior of steam into the reservoir and make the calculations for heat transfer.

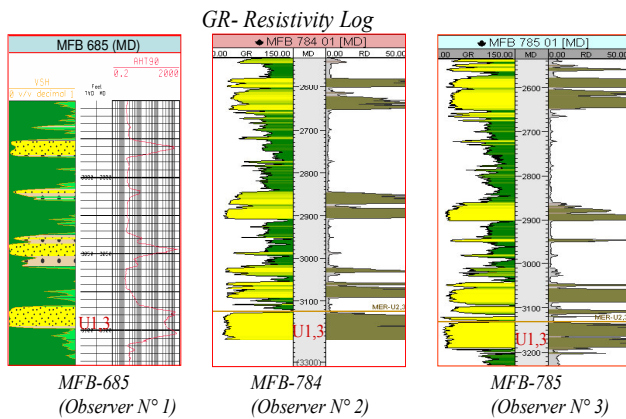


Figure # 10. GR- Resistivity logs observers wells.

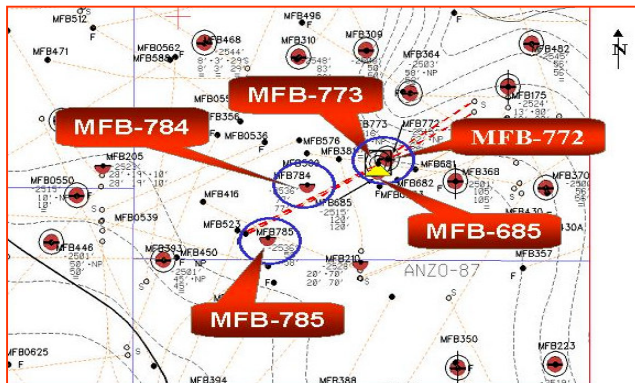


Figure # 10. Zoom of SAGD Final Settlement.

• Phase V “ Cold Information Capture”

With the purpose to validate the information provided by sensors lowered in the wells belonging to the project and to obtain the initial conditions that allow the heat transfer calculations, it was carried out data capture of static pressure and temperature in the reservoir. Through readings of optical fiber temperature it was validated the reservoir temperature at 137 ° F. This accurate monitoring system is capable of processing information every 5 minutes for every 3 feet deep in the system (Figure # 12).

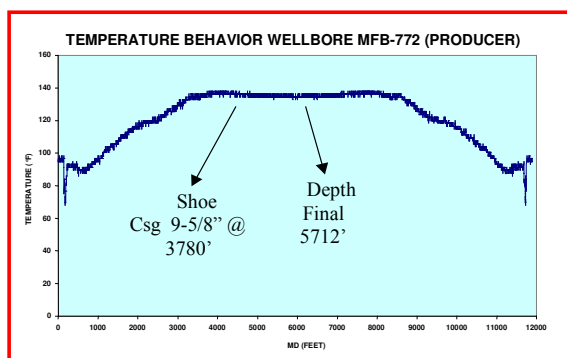


Figure # 11. Static Temp. Profile MFB-772 well.

Conclusions

- Through the application of SAGD are estimated to drain 2 MMstb, with an initial potential of 1500 stb/D.
- The production well was drilled with LWD-MWD tools, achieving a horizontal section of 2120 feet of horizontal section and 100% of net pay.
- The magnetic guidance tool helped in maintaining the parallelism and spacing planned between injector and producer wells.
- The injection well contacted 1998 feet of horizontal section and 100% net pay.
- Wells observers contacted thickness in the area of interest from 60 to 100 feet.

• The use of injection pipe pre-insulated type will reduce heat loss in the well, obtaining high quality steam in the face of the sand.

• The bottom sensors lowered into the wells, allow continuous monitoring of pressure and temperature conditions during the evaluation.

Recommendations

- Use the magnetic guidance tool in the drilling of the injector helps to maintain the parallelism and spacing planned.
- Implement the wells with pressure and temperature sensors to monitor the behavior of steam into the reservoir.
- Use injection pipe pre-insulated to minimize heat loss.
- Consider the production of H₂S in the producing well.

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