WHOC11-103

Evaluation of thermal performance in fields subjected to steam injection (SW-SAGD mode), Orinoco Oil Belt, Venezuela.

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Abstract

In July 2006, Petroleos de Venezuela S.A, completed the first well under the SW-SAGD technology in the Orinoco Oil Belt, specifically in the sand reservoir TL MFB-15, Bare field. In this case, was selected the well MFB-617, which is of horizontal geometry, drilling in the area of the reservoir with better characteristics and completed with thermal equipment as a future candidate for thermal injection processes.

To determine the behavior of steam and fell to optimize the injection pressure and temperature sensors Were placed along the wellbore high temperature fiber optic sensors and thermocouples type, through this monitoring system, information was obtained that allowed to know the behavior of steam in the background and the movement of heated fluids.

The first pilot is 3 years running, showing excellent results, we were able to increase production from 80 to 300 BNPD without decline. Current projections indicate that by the end of the project will help increase the recovery factor from 14 to 30% in the affected area of injection.

The present study is to determine the thermal behavior of the reservoir in wells subjected to steam injection by SW-SAGD technology.

Introduction

SW-SAGD process of thermal recovery method that involves injecting steam through a horizontal well pipe insulation. The steam forms a chamber whose heat is transferred mainly by conduction around the reservoir. Oil in the vicinity of the chamber is heated, reducing its viscosity and increasing mobility. Simultaneously, the heated oil is drained through a production string installed in the same well.

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

- Depth <6000 feet MD.
- Current pressure <700 psi.
- Low clay content.
- Permeability > 3 Darcys.
- Oil viscosity > 600 cps.
- Porosity > 28%.
- Net thickness > 20 feet.
- Reservoir without a layer of gas.
- Cut water < 20%.

Fiber optic temperature profiles.

This measurement system determines the temperature of each foot well away during steam injection. A beam of light passes through the optical fiber and a team placed on the surface decoder translates these light signals in temperature (see figure 1). This team decoder is based on the principle of reflectometer optical time domain and represents a cost effective system for the measurement of thousands of accurate temperature measurements.

Using this measurement tool are obtained thermal profiles of temperature, for determining the effect of the steam in the reservoir and predict the future behavior of steam injection scheme as it is raised.

The optical fiber is lowered downhole using stainless steel capillaries that prevent degradation of the contamination by unwanted fluids, thus extending their life.

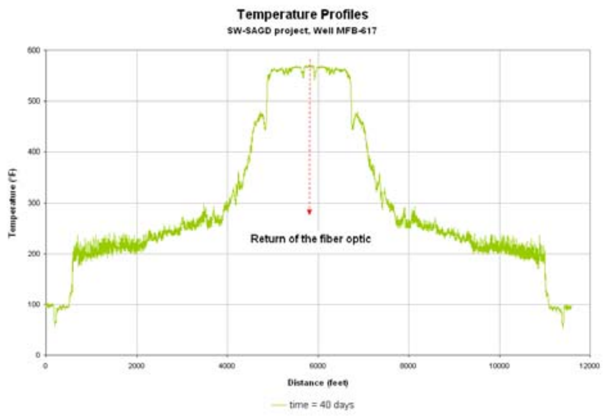

Figure # 1. Thermal profiles.

Development of SW-SAGD Project

Much of the success of the project corresponds to achieve lower dual completion planned, this consists of two strings, one production and one injection, the latter with 6 capillary straps which are incorporated optical fiber, two thermocouples and two pressure gauges; this being a special configuration never applied in the Orinoco oil belt.

From the diagram it should be noted the usefulness of each tool (see fig. 6A), pre-insulated pipe injects steam into the reservoir to reduce heat loss along its length, the zone separator serves to prevent backflow of steam to the surface forcing to penetrate the reservoir, dual keeps centralized centralizer two strings during steam injection counteracts the expansionary effects caused by the injection, capillaries strapped to the Pre-insulated string allows the injection of optical fiber to the well, and their replacement when the degradation.

The development of the project can be broken down into three phases: the first is the Stage of Completion of the well, in the planned completion is lowered, placed two string into the hole, a production and one injection, the latter with 6 capillaries straps which incorporated fiber optics, two thermocouples and two pressure gauges.

The second phase is called the heating step carried out to improve communication Well / Reservoir, it was injected 100 tons / day of steam with a quality of 80% over a period of 15 days in this phase start monitoring background parameters with sensors lowered in the completion. Finally there is the Stage of Production / Injection, which are maintained steam injection parameters and the unit is activated artificial lift.

Study of Thermal Profiles

The study started with the validation of the thermal profiles obtained by optical fiber. The selected data was collected and subjected to validation and smoothing. In the process of validating the information is studied daily the relationship between the actual temperature profiles and injection parameters, profiles were identified where problems with the actual parameters of injection were discarded to avoid complications in the study of behavior of steam. Subsequently, the data was submitted to the smoothing process in order to reduce the degree of dispersion present in this, for this is simple averages of temperature were 100 feet away, deleted Items not checked against the actual behavior of steam. Next, raw data was grouped taking into account the variables of time and depth, to determine the thermal performance according to these variables.

Discretization of the Thermal Profile Obtained

In order to study in detail the thermal profiles obtained were established 3 zones of influence of steam: an area of high temperature, transition zone and active zone (see fig. 2). The high temperature zone captures the possible formation of steam generated in field by applying this technology, the transition zone represents the heated oil-water interface as a result of the release of heat experienced by high temperature zone, and the active zone is caused by heat transfer in steam injection pipe into the formation and the heat transfer from transition zone.

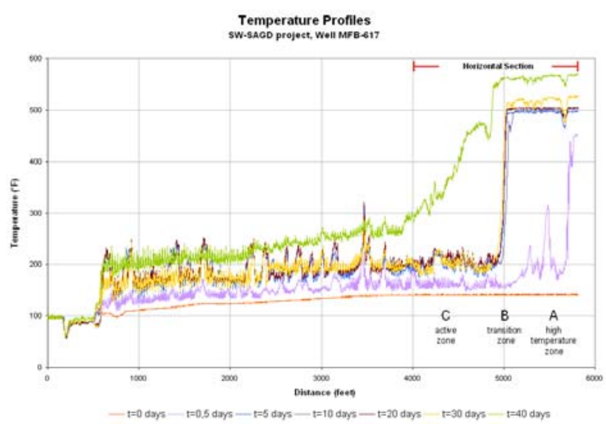

Figure # 2. Discretization of thermal profiles.

Moving the High Temperature Zone

Based on the injection scheme applied, a study of movement of the high temperature zone as a function of time. The length of this zone is a critical factor in wells subjected to SW-SAGD, as very large lengths could cause blockage of steam lifting equipment, limiting the well productivity.

According to the parameters applied in injection well is determined that the high temperature zone grows longitudinally the early days of injection at high rates of displacement (4,6 ft / day) by linear behavior as a result of static system which is subjected well. During these early days of saturated steam injection training and initiates the transfer of heat to the rock-fluid system.

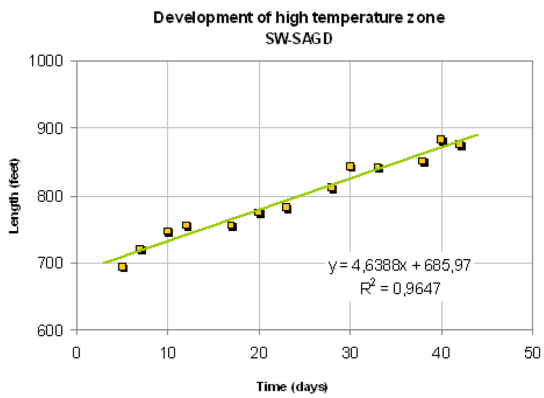

Figure # 3. Moving the high temperature zone.

Thermal Gradient Heated Fluid.

During the liberation of heat produced in the high temperature zone is formed heated fluid interface or transition zone. Generally, this area is made up of more oil from condensed water steam. The transition zone represents the fluid to be mobilized to the surface as a result of reduced viscosity and its length depends on the displacement of the zone of high temperature and the amount of heat present in it.

The results of the profiles taken in the well MFB-617 indicate that during warm-ups the transition zone shows changes in the thermal gradient of 3,49 ° F / ft until stable (see fig. 4). In the injection-production stage, occur in significant increases in temperature and displacement as a result of lifting equipment (see fig. 7A). The displacement of this area increases gradually managed to occupy much of the horizontal section. The increase in the transition zone results in greater volumes of heated fluids in training and therefore increase the recovery factor in the affected zone of injection, however, the optimum length of the transition zone must be fully related to the displacement of the high temperature zone to prevent live steam production.

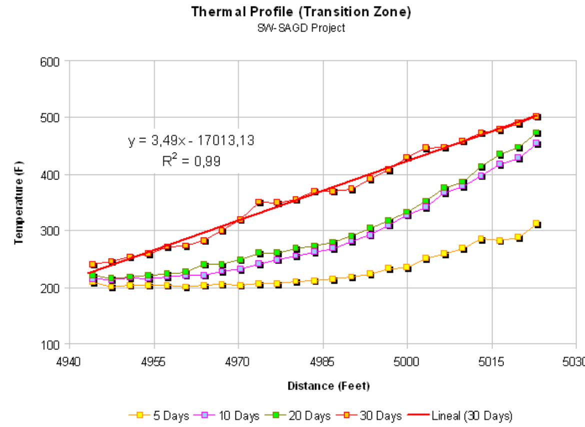

Figure # 4. Geothermal gradient transition zone (heating).

Performance of the High Temperature zone.

To determine the behavior of the high temperature zone, we performed the study of variation of temperature versus time. Under injection conditions established mathematical regressions were conducted, concluding that the potential generated in the reservoir has a logarithmic behavior, with a gradient of 36,57 °F / day. During the formation of the high temperature zone, the temperature rises sharply the first few days of injection, however, once achieved stabilization of steam injection the changes are minimal, reaching the logarithmic behavior.

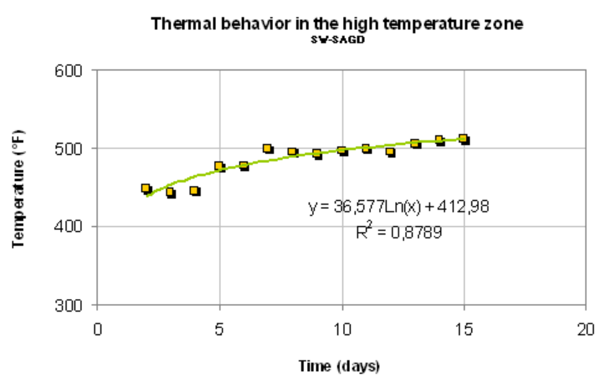

Figure # 5. Thermal behavior in the high temperature zone.

Conclusion

• The high temperature zone SW-SAGD pilot has greater displacement, the earliest days of injection.

• The operating speed of lifting equipment increases the movement of the high temperature zone, however, it is necessary to control the pump speed to prevent steam lock equipment.

• The thermal gradient of the transition zone increases with the activation of artificial lift equipment as a result of pressure drops that are generated in the reservoir,

• The increase in displacement of the transition zone is directly proportional to the volume of heated fluid.

• The high temperature zone has a logarithmic behavior, with a temperature gradient of 36,57 ° F / day.

Recommendations

• Implementation of SW-SAGD wells with pressure and temperature sensors, to determine the behavior of the steam reservoir.

• Conduct vetting the data obtained in injection model, to avoid obtaining incorrect behavior of steam.

• Calibrate temperature readings through fiber optic pressure and temperature records BHP-T.

• Lower start-type optical fiber return to verify the proper functioning of this.

Acknowledgement

The authors would like to express their gratitude to PDVSA for permission to publish the data included in this paper.

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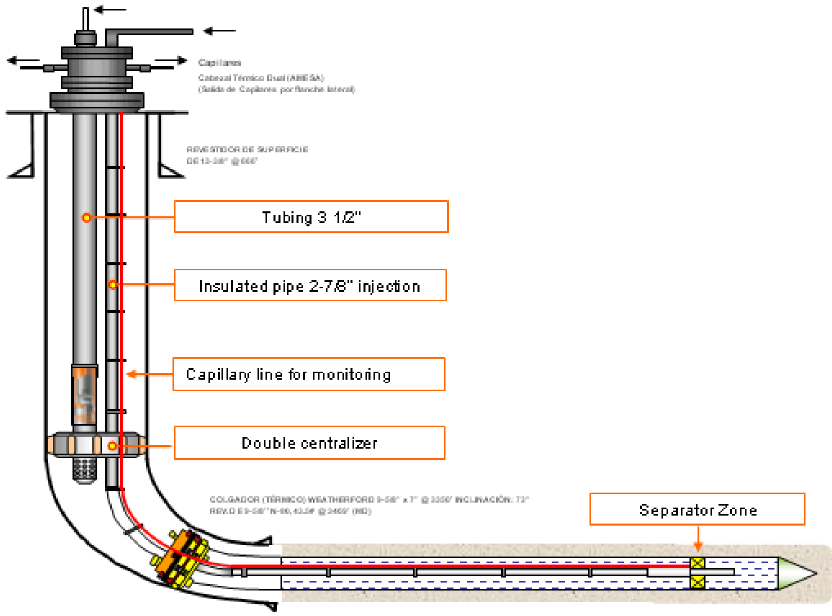

Figure # 6A. Completion SW-SAGD (Inyección- producción).

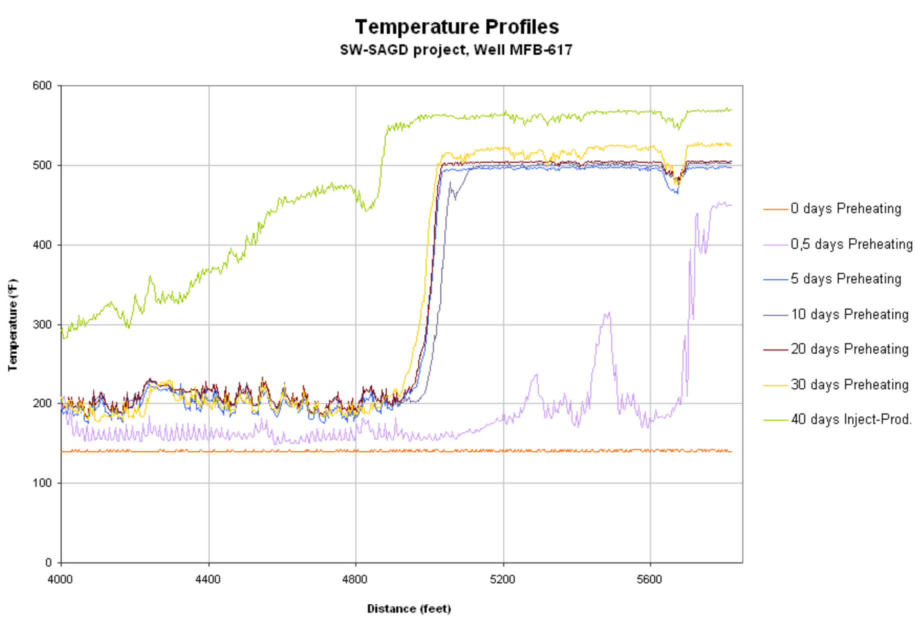

Figura # 7A. Geothermal gradient transition zone.