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Recovery of Heavy Oils Using Vapourized Hydrocarbon Solvents: Further Development of the Vapex Process

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Abstract

There are extensive deposits of heavy oil in Saskatchewan and Alberta which can only be recovered with low efficiency by conventional methods. Primary recovery in the best of these heavy oil reservoirs can yield about 6 percent of the OOIP. Waterflooding can improve the recovery, but only to an extent of 1-2 percent because of the adverse mobility ratio. Thermal recovery processes using steam can be effective, but these are uneconomic in many Lloydminster type reservoirs because the deposits are relatively thin and heat losses to the overburden and underburden are excessive.

One potential means for overcoming the problem of heat loss is to make use of vapourized hydrocarbon solvents at their dew point. This paper discusses the results of experiments with Tangleflags heavy oil and propane carried out in a large, scaled, physical model. It focuses on the area of potential problems encountered with the use of saturated hydrocarbon vapours as a solvent. In particular, it addresses the issue of precipitation of asphaltenes which may lead to reduced permeability and lower production rates. Rates, recoveries, gas to oil ratios and other important parameters will be presented and field performance of the process will be predicted from the data obtained in the scaled laboratory model.

Introduction

Production of heavy oils and bitumens from the extensive deposits in Alberta and Saskatchewan is hampered by the high viscosity of these materials caused by the high content of asphaltenes. After these heavy crudes have been produced, often by thermal methods, dilution with light hydrocarbons is required to facilitate transport through pipelines to upgrading plants and refineries. The cost of steam injection to mobilize the heavy crude is large, mostly because there are inherent heat losses associated with heating surrounding rock formations that do not bear oil. This situation is further exacerbated in thinner reservoirs.

A new idea is to recover heavy oils using saturated hydrocarbon vapours under carefully controlled conditions which lead to separation of asphaltenes from the heavy crude. The asphaltenes thus left behind are deposited on the reservoir matrix while the much lighter oil is recovered. The handling, processing and transport of such in situ upgraded oil is easier and more economical.

In our previous paper [1] we described a new process for recovering heavy oil with the aid of a saturated hydrocarbon vapour. In this paper we present further experimental data to support the feasibility of the process and explore the benefits of in situ upgrading by asphaltene removal and deposition on the rock matrix.

Experimental Work – Hot Water-propane Injection into a Packed Cell: Apparatus Development

The purpose of this work was to extend the body of knowledge obtained in our original development of the Vapex process[1] to a larger physical model in which problems not apparent in a small cell come into focus. The previous work was carried out with a small cell with inside dimensions 7 cm x 7 cm x 2.5 cm. The results were encouraging. The current project has utilized a larger two dimensional (2D) scaled model which represents a vertical cross-section through a reservoir having a pair of horizontal wells. The cell inside dimensions are 21.7 cm x 69.8 cm x 3.45 cm (Figure 1) and it is equipped with 62 thermocouples that were continually monitored by a computer. This made it possible to observe the rate and the extent of the spread of the vapour chamber, formed as a result of injecting propane near its dew point, away from the plane of injector and producer.

A diagram of the scaled up Vapex apparatus is given in Figure 2. The apparatus comprised a pressure vessel, that can operate at up to 8.3 MPa, accommodating the insulated packed 2D cell protected by a confining pressure of nitrogen and provided with 62 thermocouples, a propane cylinder and a water pre-heater tank (which were continuously weighed by independent load cells),

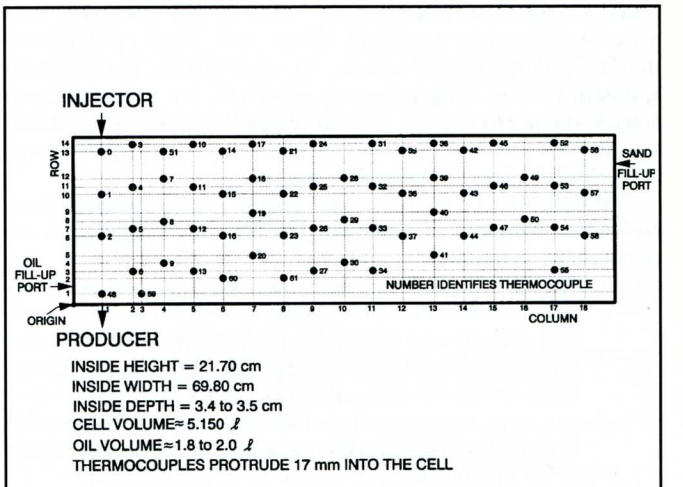

FIGURE 1: Vapex cell with 62 thermocouples.