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Preview Abstract

Design of horizontal wells and evaluation of their performance require a good description of the actual flow in their drainage area but also inside the wellbore. Indeed, frictional pressure drops due to multiphase flow inside a well fed along hundreds of metres can have a great influence on the well performance, specially for wells completed in thin oil reservoirs with an overlying gas cap or/and an underlying aquifer. This influence can be assessed by current numerical reservoir simulators, however this approach is costly and relatively uneasy to use.

In this paper, we present a fast and comprehensive model that integrates the physics of two phase flow in the wellbore, and three-phase flow in the reservoir using an analytical approach. This model allows quick and reliable computations when performing sensitivity studies for completion evaluation and reservoir engineering purposes, for instance definition of the effective length to be drilled.

The various contributions to pressure drop (gravity, friction, acceleration) are available after computation. Guidelines concerning the subdivision of well sections for an accurate evaluation of pressure drops are given.

Pressure drop calculations are compared with measurements on a well. Field examples of pressure loss forecast for reservoirs with lateral pressure maintenance or bottom aquifer support are also shown.

Introduction

Nowadays, single branch or multilateral horizontal wells are commonly used to produce oil or gas fields. These wells have larger contact areas with the reservoir than conventional vertical wells. As a consequence, for the same production, lower drawdowns are required and gas and water coning problems are alleviated.

To take full advantage of these characteristics, a horizontal well must be as long as possible. Today, drilling wells of several hundred meters horizontal reach is a common practice.

Along such wells, frictional losses create a pressure drop which may be significant compared to drawdown under the following circumstances:

- extended reach,
- high (vertical) permeability reservoir,
- small diameter borehole or production liner,
- high production rates,

- multiphase flow.

One of the most important parameter is the pipe diameter. For single phase flow, the frictional pressure drop evolves as the fourth power of the diameter in laminar regime and to the fifth power of the diameter if full turbulence prevails. Though more difficult to express analytically, the dependence is similar for multiphase flow. Moreover, multiphase flow frictional losses are much larger than single phase frictional losses. When gas or water breakthrough occurs into the well, a large increase in pressure drop occurs. Several authors have highlighted these phenomena.

Fig. 1, for instance, shows the effect of wellbore pressure drop on the lowering of a gas-oil contact. Prior to breakthrough (Fig. 1a), the single-phase pressure drop along the wellbore is small. Nevertheless, the well pressure at the heel is lower than the well pressure at the end of the wellbore. It induces a larger drawdown near the heel and a uneven lowering of the contact. As soon as the gas of the gas-cap enters the well at the entry end (heel) of the well (Fig. 1b), pressure drop in that zone increases drastically. Local drawdown climbs up and the gas-oil contact is more strongly pulled down. Obviously, to simulate such a behaviour, an accurate algorithm for wellbore pressure drop computation is required.

Wellbore Model

Several correlations or mechanistic models to predict pressure drop occurring during two-phase gas-liquid flow in a pipe have been published. We developed a short program which is able, from the input of the well characteristics, to display in a single run the pressure profiles computed by the four algorithms we have selected: Beggs&Brill, Beattie&Whalley, Pepite and Tacite. The program, initially a research tool, is open to future developments.