



SPE 115742

Advanced Wells: How to Make a Choice between Passive and Active Inflow-Control Completions

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This paper was prepared for presentation at the 2008 SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 21–24 September 2008.

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Abstract

Horizontal and multi-lateral wells allow oil and gas companies to maximise contact with reservoir quality rock in either a single reservoir or multiple reservoirs. However they do not, by themselves, guarantee optimum reservoir drainage. Premature water or gas breakthroughs frequently occur due to:

- Reservoir permeability heterogeneity,
- Variations in distance between the wellbore and the fluid contacts, particularly in compartmentalized reservoirs,
- Variations in reservoir pressure in different regions of the reservoir penetrated by the wellbore.
- Pressure drop along the completion's flow path due to friction ("heel-toe" effect).

Many such well and reservoir management problems can be mitigated by installation of downhole flow control devices – "Active" Interval Control Valves (ICVs) and "Passive" Inflow Control Devices (ICDs). ICVs were initially employed for controlled, commingled production from multiple reservoirs; while ICDs were developed to counteract the "heel-toe" effect. The variety of reservoir applications for both technologies has proliferated so that their application areas now overlap. Appropriate selection between an ICV and an ICD completion can be both a complex and a time consuming process.

This paper compares the functionality and applicability of the two technologies. Completion Design selection guidelines are developed based on multiple criteria drawn from reservoir, production, operation and economic factors. Reservoir engineering aspects, such as uncertainty management, formation heterogeneity, and the level of flexibility required by the development are analyzed. Production and completion characteristics, such as tubing size, the number of separately controllable completion zones, the installation of multiple laterals and the value of real time information were also investigated. This systematic analysis forms the basis of a screening tool to identify the optimum technology for each particular situation.

This study provides a robust, comparative framework for both production technologists and reservoir engineers to select between passive and active flow control for optimised, advanced well completions.

1. Introduction

Increasing well-reservoir contact has a number of potential advantages in terms of well productivity, drainage area, sweep efficiency and delayed water or gas breakthrough. However, such long, possibly multilateral, Maximum Reservoir Contact (MRC) wells bring not only advantages by replacing several conventional wells; but also present new challenges in terms of drilling and completion due to the increasing length and complexity of the well's exposure to the reservoir [58]. The situation with respect to reservoir management is less black and white. An MRC well improves the sweep efficiency and delays water or gas breakthrough by reducing the localized drawdown and distributing fluid flux over a greater wellbore area; but it will also present difficulties when reservoir drainage control is required.

Production from a conventional well is normally controlled at the surface by the wellhead choke; increasing the total oil production by reducing the production rate of a high water cut, conventional well afflicted by water coning. Such simple measures do not work with an MRC well, since maximization of well-reservoir contact does not by itself guarantee uniform reservoir drainage. Premature breakthrough of water or gas occurs due to:

1. Reservoir permeability heterogeneity.
2. Variations in the distance between the wellbore and fluid contacts e.g. due to multiple fluid contacts, an inclined wellbore, a tilted oil-water contact, etc.
3. Variations in reservoir pressure in different regions of the reservoir penetrated by the wellbore.