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Advanced Wells: A Comprehensive Approach to the Selection between Passive and Active Inflow Control Completions

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Abstract

Advances (from conventional wells to horizontal and then multi-lateral) in well architecture for maximising reservoir contact have been paralleled by advances in completion equipment development of both "Passive" Inflow Control Devices (ICDs) and "Active" Interval Control Valves (ICVs). These devices provide a range of fluid-flow control-options that can enhance the reservoir sweep efficiency and increase reserves. ICVs were initially employed for controlled, commingled production from multiple reservoirs; while ICDs were developed to counteract the "Heel-Toe" Effect. The variety of their reservoir applications has since proliferated, so that their application areas now overlap. It has become both complex and time consuming to select between ICVs or ICDs for a well's completion.

This publication along with a companion paper summarises the results of a comprehensive, comparison study of the functionality and applicability of the two technologies. It maps out a workflow of the selection process based on the thorough analysis of the ICD and ICV advantages in major reservoir, production, operation and economic areas. Detailed analysis of the modelling, gas and oil field applications, equipment costs and installation risks, long term reliability and technical performance are covered. The systematic approach and tabulated results of this comparison forms the basis of a screening tool of the potential applicable control technology for a wide range of situations.

The selection framework can be applied by both production technologists and reservoir engineers when choosing between "Passive" or "Active" flow control in advanced wells. The value of these guidelines is illustrated by their application to synthetic and real field case studies.

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, Extreme Reservoir Contact (ERC) 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 [1]. The situation with respect to reservoir management is less black and white. An ERC well improves the sweep efficiency and delays water or gas breakthrough by reducing the localized drawdown and distributing fluid flux over a greater wellbore length; 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 ERC 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.
4. The "heel-toe" effect that leads to a difference in the specific influx rate between the heel and the toe of the well, especially when the reservoir is homogeneous.