OTC 20131

Simulation and Optimization of Complex Architecture Wells With Smart Completions

Jamil Al-Thuwaini, SPE, Shamsuddin Shenawi, SPE, and Bevan Yuen, SPE, Saudi Aramco

This paper was prepared for presentation at the 2009 Offshore Technology Conference held in Houston, Texas, USA, 4–7 May 2009.

Abstract

Multilateral-well technology improves well productivity by maximizing reservoir contact, resulting in field development with fewer wells and minimizing water and gas coning. The current practice of drilling long horizontal wells (up to eight km) poses the greatest technological challenge in completing the wells because of geological uncertainties, hydraulical and mechanical complications. Tremendous efforts have been made by the oil industry to meet these drilling challenges, and also in the design and completion of these types of wells. Since 2002, over 440 horizontal, multilateral and maximum reservoir contact (MRC) wells have been drilled and equipped with active Inflow Control Valves (ICV) and passive Inflow Control Devices (ICD) in Saudi Aramco. The complex architecture of those wells generally makes them more expensive to drill and complete. Therefore, their use must be justified and well planned. The planning of complex architecture wells requires thorough modeling studies to optimize total length, configure branches, place ICV and ICD along the motherbore to achieve balanced inflow along the horizontals, overcome high frictional pressure loss from heel to toe, alleviate reservoir pressure variation along the laterals, decrease coning or cusping of gas and water, and control gas or water production from offending laterals.

Advanced well completion technology, which improves well productivity and maximizes sweep, is becoming the main stream development technology in Saudi Aramco. Numerous future wells and reentries are planned as complex architecture wells with smart completions. Realizing the important role of reservoir simulation, and the difficulties of modeling and optimizing of these complex architecture wells, Saudi Aramco embarked, in 2002, to develop simulation technologies for the evolving complex architecture wells with smart completions.

In-house simulation and optimization efforts for complex architecture wells with smart completions have increased drastically since 2002. In fact, two industry joint projects, with a service provider, developed a new simulation workflow for the complex architecture wells with smart well completions. This paper will present simulation, design and optimization of four field cases with complex architecture wells equipped with ICD and ICV. Well configurations, geologic uncertainty and placements of ICD and ICV along the laterals are optimized using the neural network, genetic algorithms, and proxy models.

Introduction

Worldwide drilling of horizontal wells increased in the mid-1980. Beliveau (Beliveau 1995) compared production performance of horizontal wells with offsetting vertical wells. He calculated the production improvement factor (PIF) for 1306 horizontal wells from 230 fields around the world. The calculated PIF's showed log-normal distribution caused by geologic heterogeneities compounded by mechanical drilling and completion effects. The results revealed a mode PIF of 2, a median PIF of 3, and a mean PIF of 4. One benefit of horizontal wells is that they can seek out more sweet spots (more permeable area or zone) by drilling through or contacting more reservoir rock. Many other factors such as length of the horizontal laterals, wellbore configuration, formation damage (skin), reservoir pressure profiles, unexpected fractures, and baffles affect the rate distribution along the horizontal wellbore.