



OTC 20129

Optimizing Horizontal Well Performance in Nonuniform Pressure Environments Using Passive Inflow Control Devices

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

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Abstract

Passive Inflow Control Devices (ICDs) are used to enhance performance of horizontal wells in unfavorable environments, such as nonuniform permeability and/or pressure along horizontal sections. This is the first attempt at using ICDs to manage inflow along horizontal wells with substantial reservoir pressure differential.

This paper presents how passive ICD completion technology is used to optimize well productivity and reduce water production in a well with significant reservoir pressure differential across the horizontal section. Prior to running the ICDs, this horizontal carbonate well exhibited a nonuniform production profile, cross-flow, and high water production resulting in reduced well performance.

A production log of the initial (open hole) completion confirmed downward cross-flow of fluids from heel to toe and production contribution from only the first 10% of the horizontal section. Following the installation of the ICD system, water production was greatly reduced and oil rate doubled indicating significant improvement of the well performance. A second PLT survey showed contribution from the entire horizontal section and elimination of the cross-flow.

The key factor in the success of this project was the ICD system design derived from numerous wellbore hydraulic simulations, determining the appropriate number of ICD units and compartments.

Introduction

Horizontal wells have been globally used to maximize reservoir contact and ultimately improve well performance. Variations in permeability, pressure and frictional pressure drop along horizontal sections can create nonuniform inflow profiles, which can lead to early breakthrough of water or gas in reservoirs with an aquifer and/or gas cap. Breakthrough typically occurs in regions of high permeability or at the heel of the lateral section in homogenous reservoirs. This ultimately leads to a reduction in reserve recovery and well performance.

The use of ICD systems to effectively manage nonuniform inflow profile has been described in past publications¹⁻⁴. In this paper, ICDs were used to control nonuniform pressure profile. The variation in reservoir pressure was 200 psi from heel to toe, with high pressure at the heel.

Background

Horizontal wells are common practice in this giant Middle East field with a production history of more than 50 years. The reservoir is a composite Jurassic carbonate anticline, with several gently dipping crestal regions containing undersaturated Arabian Light grade oil. Full pressure maintenance was initiated in the 1980s by peripheral power water injection. Infill drilling is still underway tapping oil behind the flood front areas utilizing horizontal well technology. The most prolific zones in this gravity dominated reservoir exhibit high matrix (300 mD - 2,000 mD) permeability, which is the principal source of production.