OTC 19811

New Inflow Control Device Reduces Fluid Viscosity Sensitivity and Maintains Erosion Resistance

Martin P. Coronado, SPE, Luis A. Garcia, SPE, Ronnie D. Russell, SPE, Gonzalo A. Garcia, SPE, and Elmer R. Peterson, Baker Hughes Incorporated

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

Abstract

In long horizontal wells, production rate is typically higher at the heel of the well than at the toe. The resulting imbalanced production profile may cause early water or gas breakthrough into the wellbore. Once coning occurs, well production may be severely decreased due to limited flow contribution from the toe. To eliminate this imbalance, inflow control devices (ICDs) are placed in each screen joint to balance the production influx profile across the entire lateral length and to compensate for permeability variation.

Pressure drop in an ICD is created through either restriction or friction mechanisms. Restriction mechanisms rely on a contraction of the fluid flow path to generate an instantaneous pressure drop, resulting in higher velocities, and are thus more prone to long-term erosion damage as well as plugging during mud flowback. A restriction device, however, is less sensitive to viscosity properties of the fluid. A frictional device, which creates a pressure drop over a distributed length, is less likely to erode due to lower fluid velocities, but is more sensitive to viscosity changes. Viscosity insensitivity is desired to minimize preferential water flow whenever water breaks through into the well.

This paper will detail the development of a new hybrid design concept that uses the best features of the restricting and friction designs, while minimizing the less desirable characteristics. Because these ICDs are permanent downhole components, their long-term reliability is imperative, and these new developments will improve their resistance to erosion and their ability to effectively balance inflow. Conceptual fluid dynamics analysis was used extensively to characterize the new design, along with actual full-scale flow testing.

Introduction

The purpose of inflow control devices (ICDs) is to effectively balance well production throughout the entire operational life of the completion to optimize hydrocarbon recovery. Since a typical well with ICDs can be in production from 5 to >20 years, the long-term reliability of such a device is crucial to the well's overall success. The significant factor in the reliability of an ICD is its ability to maintain a uniform influx over the well life. If an ICD is not able to maintain a uniform flux rate, increased localized production rates will occur and the well will become unbalanced. This will render the ICD ineffective, leading to premature water and/or gas breakthrough and possible loss of sand control. At some stage in a well's life, water may break through into the wellbore in certain sections due to heterogeneity of the formation and/or vertical fractures. Ideally, once this occurs, flow contribution from these water-producing zones should not be greater than the oil-producing sections. In production wells with higher-viscosity oil (>10 cp.), ICD type selection becomes a more critical factor due to the larger difference in viscosity between the oil and produced water. The pressure reduction mechanism in an ICD in this situation must have the lowest sensitivity to viscosity to maintain an even flow profile across the entire lateral wellbore. A restrictive-type ICD thus will provide best results in this regard due to its lower sensitivity to viscosity. This type of ICD however, has a greater potential for long-term erosion and lower plugging resistance.

The ideal solution is to provide the lower viscosity sensitivity of the restrictive device with the lower erosion and higher plugging resistance of the frictional design. This means using the restrictive pressure loss mechanism while limiting the fluid velocity through the device below the critical level which will cause erosion. Limiting the fluid velocity also can result in increased minimum flow area if configured efficiently.

The primary factor in maintaining a uniform influx is the ability of the device to resist erosion from fluid-borne particles that pass through the screen. Screens are not designed to prevent 100% blockage of all particles from the formation. During