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Examining Erosion Potential of Various Inflow Control Devices to Determine Duration of Performance

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Abstract

When producing long, horizontal zones, 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 (sandstone formations) or debris barrier (carbonate formations) to balance the production influx profile across the entire lateral length and compensate for permeability variation. This creates equal production through each joint of screen to maximize recovery and rate.

Pressure drop is created through restriction or friction mechanisms. Restriction uses small holes or orifices to restrict flow. Friction utilizes surface friction of a long channel to create the required pressure drop. ICDs to effectively balance production inflow depend upon their ability to resist erosion. Because these ICDs are permanent downhole components, their long-term reliability is imperative.

Factors that determine erosion potential of ICD designs are fluid velocity, fluid particle concentration and design geometry. Calculations and computational fluid dynamics (CFD) modeling can be used to predict values for several factors independently, but not as a complete system. A full-scale erosion test is the most accurate way to demonstrate how the interaction of erosion factors affects the long-term reliability of downhole components.

This paper will detail the methodology behind ICD design, the use of CFD analysis in determining erosion potential, as well as the analysis of full-scale ICD erosion testing conducted at an independent testing laboratory.

Introduction

The purpose of inflow control devices 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.

The primary factor in maintaining a uniform influx is the ability for the device to resist erosion from fluid borne particles. During production, formation fines that are produced through the screen also pass through the ICD. These fines can and will erode an ICD over time. The rate of erosion will depend on the following factors: particle size, particle concentration and fluid velocity. The first two factors are dependent on well conditions, while the third is dependent on ICD geometry and design.

Currently, there are two different types of ICD designs in the industry: orifice and helical-channel. They use two different methods to achieve a uniform inflow profile. The orifice type ICD uses fluid constriction to generate a differential pressure across the device. This method essentially forces the fluid from a larger diameter down through a smaller diameter, creating a back pressure. This overall change in pressure is what allows the ICD to function. The helical-channel ICD, however, uses surface friction to generate a similar pressure drop. The helical channel design is one or more long flow channels that are wrapped around the basepipe of the screen. When fluid flows through the channels, fluid rheology and channel characteristics interact to create a designed pressure drop.

In order to predict how the two concepts resist erosion, CFD analysis was first run using a 3-D model of each. This analysis predicted the fluid velocity of the two designs, as well as where the maximum values of fluid kinetic energy are located. Currently, these values determined through CFD analysis are only able to predict where erosion will likely occur, not how much dimensional change or weight loss that will result. To accurately determine how the two concepts erode, a full-scale test was required. The full-scale test pumps