Oilfield Bulletin

Focus on Completions Optimization in Horizontal Wells

WellSteer

Performance of Horizontal Wells Completed with Slotted Liners and Perforations

Horizontal wells are one of the most important strategic tools in petroleum exploitation. As a result of the advances in drilling and completion technologies in the last two decades, the efficiency and economy of horizontal wells have significantly increased. Today, horizontal well technology is applied more often and in many different types of formation. The state of the art applications of horizontal well technology require better completion designs to optimize production rates, long-term economics, and ultimate producible reserves.

Horizontal well completions can be categorized as natural completion, sand-control completion, and stimulation completion. Natural completion includes open-hole, slotted-liner, and cased and perforated completions. Sand-screens, prepacked screens, and gravel packing are the completions used for sand – control. Stimulation completion includes completion with hydraulic fracturing and fracturing with gravel packing (fracpack or stimpack).

In a horizontal well, depending upon the completion method, fluid may enter the wellbore at various locations and at various rates along the well length. The complex interaction between the wellbore hydraulics and reservoir flow performance depends strongly on the distribution of influx along the well surface and it determines the overall productivity of the well. Therefore, the optimization of well completion to improve the performance of horizontal wells is a complex but very practical and important problems. The complexities of the numerical simulation of horizontal well completions make analytical models extremely attractive. However, the inherent difficulties of the analytical solutions caused by the complex flow geometries, excessive number of perforations or slots, and nonuniform distribution of flux along the well calls for the challenging task of developing efficient process.

We analyze completions of horizontal wells with perforations and slotted liners. We investigate the effect of well completion on horizontal well performance coupling reservoirs and wellbore flow equations. For the reservoir parts, perforations and slots are modeled as line sources. The mothod of sources and sinks and principle of superposition are used to derive the expression for the reservoir pressure drop along the well surface. These expression take into account the 3D convergence of flow towards perforations and slots. The wellbore model considers the pressure losses inside the well and effect of influx from the reservoir into the horizotal well. The final coupling of the reservoir and wellbore flow components is accomplished by using the continuity requirement of the pressure and flux at the reservoir-wellbore interface.

Guidelines for Horizontal Well Completions

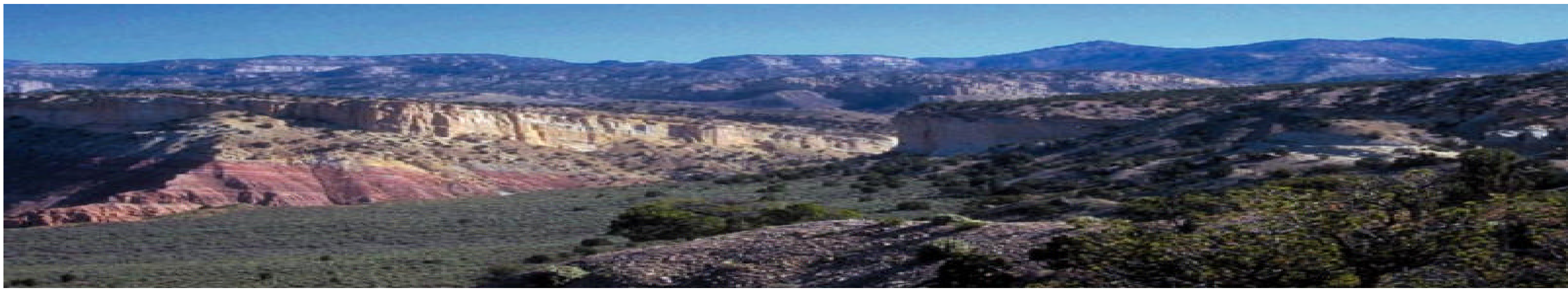
? Both perforation penetration (lengh) and density have significant impact on horizontal well productivity

? For perforating in isotropic formations, we recommend to use 90° phasing because it has the smaller pressure drop due to flow convergence around perforations and less frictional pressure loss in the wellbore. For severely anisotropic reservoirs, perforating with 360° or 180° phasing along vertical direction yields the largest productivity. This is also different from the perforation practices for vertical wells.

? For slotted-liners completion, the use of small phasing angles, such as 30°, 60°, or 90° is recommended. As the anisotropy becomes more severe, smaller phasing angles should be used.

? The slot penetration ration (slotted section length over the total section length) has significant effect on the productivity of the horizontal well.

? Horizontal well productivity is also significantly affected by the slot size.



Inflow Analysis and Optimization of Slotted Liners

Slotted liners are commonly used to provide sand control in unconsolidated heavy-oil reservoirs. The primary factors considered in their design are sand control, inflow resistance and cost. Inflow performance is usually considered to be controlled by the area exposed to the reservoir, and sand control governed by slot opening size. These becomes competing considerations in reservoirs with fine sands because slot density must be increased to maintain open area if slot size is reduced to control sand.

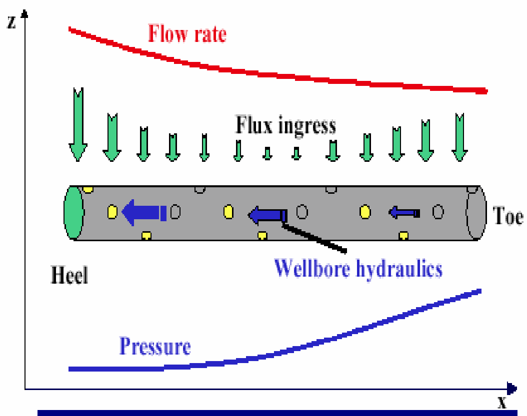
Furthermore, it is difficult to cut narrow slots, which previously made narrow opening sizes unachievable for slotted liner. Recent developments in slotted liner technology have addressed this last issue, allowing very small slot widths with good anti-plugging characteristics to be manufactured economically.

Although small slot-opening are available, their size would demand very high slot density to maintain the open-area targets often specified. The basis for this requirement probably stems from applying channel flow concepts to flow loss through the slots. This basis also leads to the conclusion that fewer, large slots would have less flow resistance than more, small slots for the same open area. However, the basis for such conclusion ignores the most important component of slot-induced flow loss – flow convergence in the sand that packs around the slots. In fact, the flow loss through an open slot is negligible compared with that induced by the flow disturbance associated with the slot.

Guidelines for Design of Slotted Liners

Detailed analysis of slot-induced flow resistance demonstrated that slot spacing and density are the dominant controlling parameters for inflow resistance of slotted liners. Slot size and open-area play minor roles in throttling inflows. This allows greater freedom in selecting geometry to control sand and provide structural integrity, subject to cost considerations. Therefore, slot geometry should generally be chosen to preclude sand entry and prevent bridging inside the slot. Increasing slot width to provide more open-area can be counter-productive because it can lead to slot plugging and higher flow losses. Resources should be focuses instead on preventing plugging from developing in the slots. In addition, for thermal application that generates significant axial loads, the slot density can be reduced to increase the load tolerance of the liner, without drastically compromising the inflow characteristics of the system.

A conventional liner design that minimizes inflow resistance generates a significant variation in inflow and pressure draw down in the reservoir from heel to toe. Reducing the liner size increases the variation dramatically.



Effect of horizontal well completion on reservoir influx and wellbore hydraulics

At 178mm diameter, inflow at the heel with idealized reservoir conditions is 43% higher than at the toe. At 140mm and 102mm, production at the heel is respectively 137% and 839% higher than at the toe. Actual variations will be controlled by the steam chamber configuration, but the tendency is for flow redistribution due to pipe flow losses.

Usually, a slot distribution is optimized for nominal production conditions, and variations from those conditions provide a favorable redistribution toward the toe.

Please visit us at;
www.wellsteer.com or e-mail
info@wellsteer.com