Optimal Horizontal Well Placement Technology to Improve Heavy Oil Production

Mehrdad Alemi, Hossein Jalalifar

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***Abstract:** Optimal horizontal well placement and production optimization have been highly scrutinized. Development adjustments, such as drilling new infill wells and changing the injection/production rates of wells, can improve the performance of mature fields and leading to incremental oil recovery. Infill wells are new wells added to an existing field within original well patterns. Infill drilling can hasten oil production in heterogeneous reservoirs. If well patterns alter, fluid flow paths and sweep to areas with high oil saturations would be increased. Of course, this plan is difficult to be examined because reservoir performance is affected by many different parameters. Compared to vertical or low inclination wells, horizontal wells can deliver higher production rates, higher recovery factors and more efficient use of steam in thermally enhanced recovery projects for heavy oil. Maximum oil production is achieved when horizontal wells are placed near the bottom of the reservoir. In addition, cumulative steam to oil ratio is lowest when wells are near the bottom of the reservoir, meaning that the least volume of steam will need to be generated to produce a particular volume of oil. In this paper, the optimal horizontal well placement technology to improve heavy oil production has been studied.*

***Keywords:** Optimal Horizontal Well Placement, Production Optimization, Drilling New Infill Wells, to Improve Heavy Oil Production.*

I. INTRODUCTION

Gas and/or water coning encountered in many oil wells is a serious problem which results in lower oil production rates, lower oil recovery, increased lifting cost and ineffective solution-gas drive mechanisms. The main forces acting on the reservoir fluids besides capillary forces are gravity and viscous forces. Gravity forces are due to the density differences of reservoir fluids such as water-oil and gas-oil and viscous forces are due to fluids production and wellbore drawdown pressure. The pressure gradient forces, which depend on the oil production rate, tend to lift the water- and/or gas- oil interface in a direction perpendicular to the formation bedding plane, whereas the gravity forces tend to separate the oil, gas and water phases.

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When the viscous forces overcome the gravity forces the gas-oil and water-oil interfaces start to move toward the production well until they reach the producing well. This phenomenon is referred to as coning or cresting in vertical or horizontal wells, respectively, and the time at which the unwanted fluid (water or gas) reaches the producing well is termed breakthrough time. Traditionally, due to technological restrictions and economic considerations, wells were drilled mainly vertical to the oil bearing formation. However, due to recent advances in oil-well drilling technology and a decrease in drilling cost, horizontal wells are now being drilled routinely to drain oil reservoirs. One of the main advantages of the horizontal wells compared to vertical wells is that it reduces pressure depression in the well's neighborhood due to the smaller flow rate per unit length of the well for a given production rate.

Therefore, horizontal wells tend to attract the fluid contacts more uniformly over a larger area than vertical wells and, therefore, decrease the tendency of the water and gas to "cone" into a producing well. Especially in thin oil zones, located between the bottom water and gas cap, horizontal wells have substantially reduced the coning effects. The intensity of the coning phenomenon generally depends on the pressure drawdown in the neighborhood of the producing well, the viscosity and density of the water and gas compared to the oil phase, and the vertical and horizontal formation permeability. The time at which water or gas reaches the producing well can be delayed by increasing the offset of the well with respect to the WOC or GOC, respectively. In this case, however, because the oil zone exists in between a water and a gas zone, the water and gas coning times generally will be different if the horizontal well is designed so that the offset of both WOC and GOC is maximized, i.e., the well is placed at the center of the oil zone.

This is because the mobilities and densities of the water and gas phases are significant different. It is intuitively apparent that there would be a location within the oil zone at which both water and gas fluids cone simultaneously into the horizontal well; at this location the pre-breakthrough time, cumulative oil production is maximize. Knowledge of the breakthrough time is very significant for effective oil well management and for extending the oil production time of the well without the presence of water or free gas. [T. Wagenhofer ; D.G. Hatzignatiou, SPE-35714-MS, 1996].

II. MATERIALS AND METHODS

Generally, optimal horizontal wells placement as one in injector at the top and one producer both as close as possible at the bottom of the heavy oil reservoir can help for incremental oil recovery. of course if the length and also the vertical distances of the pair wells be optimized. The existence of as much as vertical fractures can also be helpful. In this study the used method would be by means of reservoir simulation.

III. RESULTS AND DISCUSSION

Maximum oil production is achieved when horizontal wells are placed near the bottom of the reservoir. In addition, cumulative steam to oil ratio is lowest when wells are near the bottom of the reservoir, meaning that the least volume of steam will need to be generated to produce a particular volume of oil. Infill wells should be located at non-intersected areas of the reservoir other injection-production wells streamlines paths which are un-swept zones of oil. Of course if the length and also the vertical distances of the pair wells be optimized. In following the heavy oil reservoir simulation scenarios has been achieved:

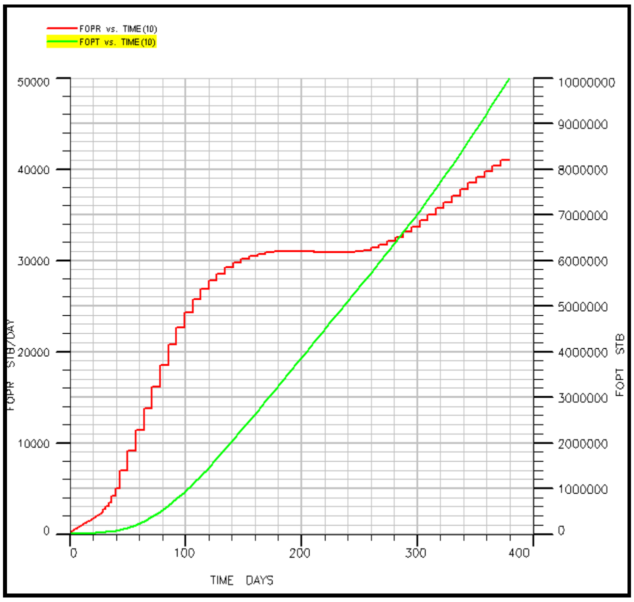

Figure: 1. FOPR & FOPT-Time in thermal recovery process

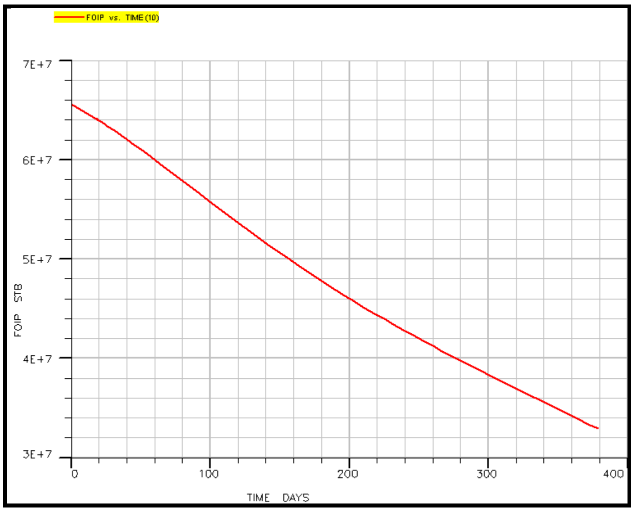

Figure: 2. FOIP-Time in thermal recovery process

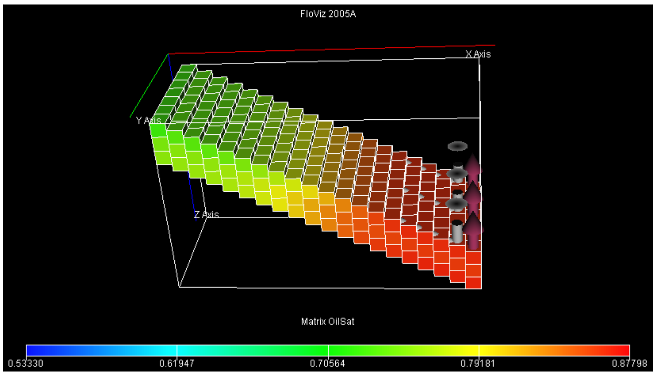

Figure: 3. Matrix oil saturation in thermal recovery process with such a horizontal wells placement

If huff-puff wells were used, the results would be as the following:

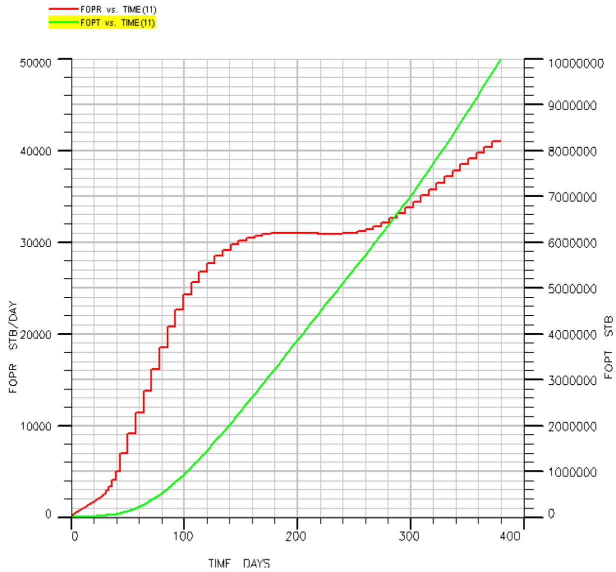

Figure: 4. FOPR & FOPT-Time in huff-puff thermal recovery process

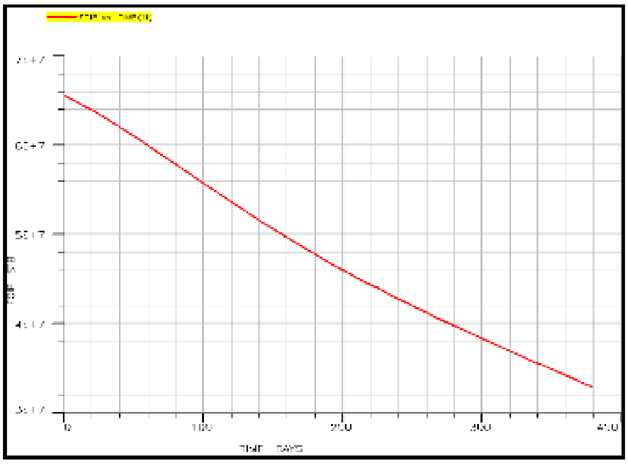

Figure: 5. FOIP-Time in huff-Puff Thermal Recovery Process

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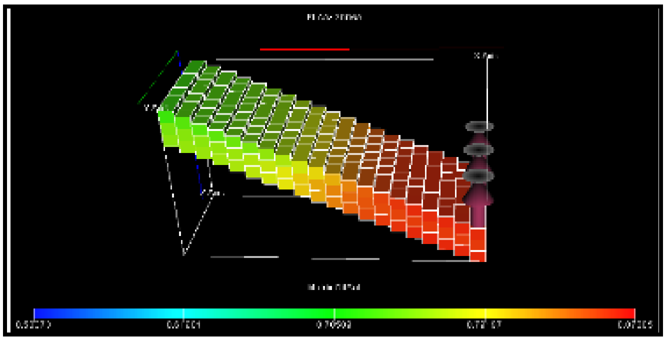

Figure: 6. Matrix oil saturation in huff-puff thermal recovery process with such a horizontal wells placement

The well placement configuration of injectors are above the producers all horizontal and parallel with each other producing heated heavy oil (high mobility oil). Horizontal wells are placed near the bottom of the reservoir. the more vertical fractures between the two wells and higher permeability anisotropy, the better that the vertical distance of the two well be greater and vice versa. As well the longer the horizontal section, the more recovery would be gained.

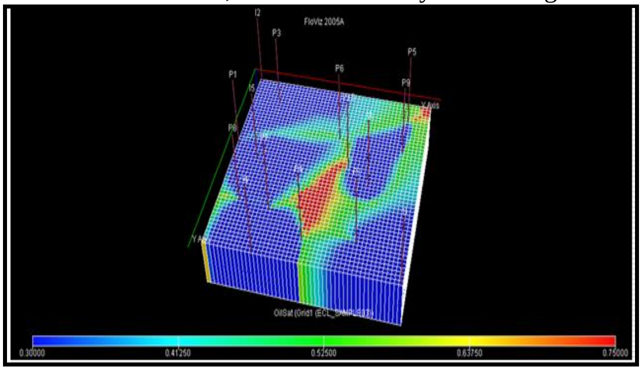

Figure: 7. Example reservoir with water injection & production wells after water flooding process

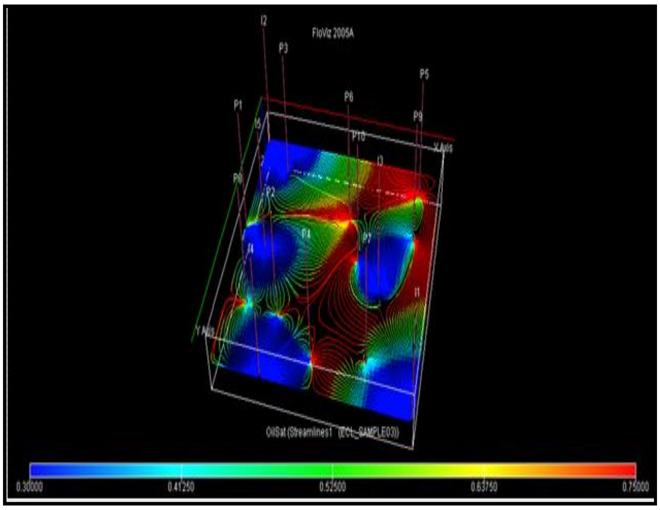

Figure: 8. Streamlines with water injection & production wells during water flooding process

According to what has been shown in figure 7-8, in the example reservoir that water flood has been applied in it, the location with lack of drainage area intersection of all the injection and production wells, the un-swept (red) location can be a good candidate for infill drilling another production well for incremental oil recovery in this reservoir.

IV. CONCLUSIONS

1. In this paper, the optimal horizontal well placement technology to improve heavy oil production has been studied.
2. Maximum oil production is achieved when horizontal wells are placed near the bottom of the reservoir. Infill wells should be located at non-intersected areas of the reservoir other injection-production wells streamlines paths which are un-swept zones of oil. Of course if the length and also the vertical distances of the pair wells be optimized. In other words, the well placement configuration of injectors are above the producers all horizontal and parallel with each other producing heated heavy oil (high mobility oil). Horizontal wells are placed near the bottom of the reservoir. The more vertical fractures between the two wells and higher permeability anisotropy, the better that the vertical distance of the two well be greater and vice versa. As well, the longer the horizontal section, the more recovery would be gained.
3. In the example reservoir that water flood has been applied in it, the location with lack of drainage area intersection of all the injection and production wells, the un-swept (red) location could be a good candidate for infill drilling another production well for incremental oil recovery in this reservoir. Development adjustments, such as drilling new infill wells and changing the injection/production rates of wells, could promote the performance of mature fields and resulting in more oil recovery. Infill wells are new wells added to an existing field within original well patterns. Infill drilling can hasten oil production in heterogeneous reservoirs. If well patterns alter, fluid flow paths and sweep to areas with high oil saturations would be increased because well spacing is decreased. Of course, this plan is difficult to be examined because reservoir performance is affected by many different parameters.

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Authors Contributions	All authors having equal contribution for this article.

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