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A selection method of the horizontal wells completion

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This article has been **RETRACTED** at the request of the editor.

Reason: it was brought to our attention that the paper "**A selection method of the horizontal wells completion**" by **Dusan Danilović, Vesna Karović Maričić and Ivica Ristović**, published in *Acta Montanistica Slovaca*, vol. 11 (2006), special issue 1, pages 31-35, contains material that was taken from a previously published paper by Ali A. Garrouch, Haitham M. S. Lababidi and Abdullah S. Ebrahim in *Journal of Petroleum Science and Engineering*, 2004.

After carefully reviewing both papers it was determined that the article indeed contains a great deal of text that is identical to the paper published by Garrouch *et al.* without appropriate attribution. The original publication is "An integrated approach for the planning and completion of horizontal and multilateral wells", Ali A. Garrouch, Haitham M. S. Lababidi and Abdullah S. Ebrahim, *Journal of Petroleum Science and Engineering*, volume 44, issues 3-4, 15 November 2004, pages 283-301 (doi:10.1016/j.petrol.2004.03.007).

A selection method of the horizontal wells completion

Dusan Danilović*[1], *Vesna Karović Maričić* and *Ivica Ristović

Výber vystrojovania horizontálnych vrtov

The completion of horizontal wells can be done by different ways and depends on production constraints and the reservoir characteristics.The selection of a completon method is directly influenced by the degree of rock consolidation, the need for water or gas shut off,the anticipated flow rate, the completion longevity, the shale reactivity and the stability, the degree of grain sorting and the lamination.

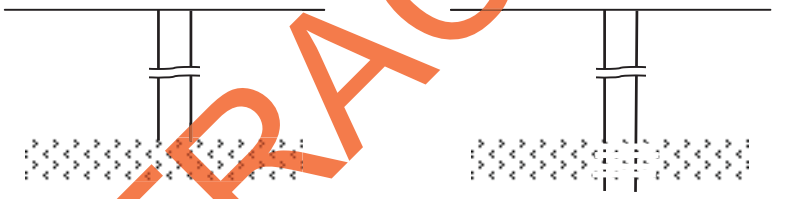
In this article, the possible methods for the horizontal well completion are shown. Also, it is presented the horizontal well completion selection flowchart. This algorithm is made on the basis of a large number of wells' analysis considering reservoir characteristics and production constraints.

***Key words**: completion, horizontal well*

Introduction

Drilling and completing of wells can be done by different ways. In general, three main approaches can be defined:

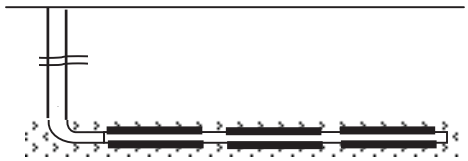
- Vertical well drilling with an opeh hole (Fig.2a) or casing (Fig 2.b)
- Vertical well drilling with one (Fig. 3a) or more open intervals (Fig. 3b)
- Multilateral well drilling (it means drilling of more horizontal wells from one vertical-Fig 4)



Slika 2a

Slika 2b

Slika 3a



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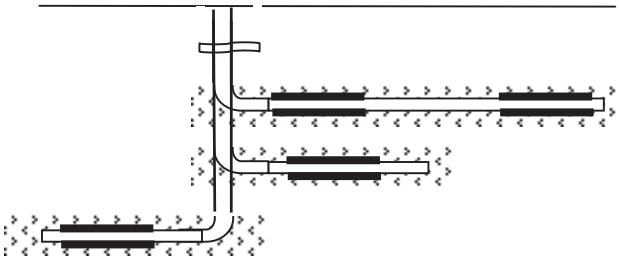

Slika 4

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Horizontal wells are mainly used for the production increase compared to vertical wells. Since they have a much greater contact to the reservoir than vertical wells, the production by horizontal wells is greater. Also, the horizontal wells have an large application for solving various problems occuring during the vertical wells production.

The Methods of Horizontal Well Compeltion

The various lateral section completion offers varying degrees of efficiency for the ability to manage the reservoir. Some of these are basic, while others are complex. The selected completion method must be designed to fit the production constraints and the reservoir characteristics. The completion options also depend on the degree of rock consolidation, on the need for water or gas shut off, the anticipated flow rate, the completion longevity, the shale reactivity and the stability, the degree of grain sorting and the lamination. The wellbore stabilization is of a primary concern. For laminated formations, a gravel pack stresses the formation and immobilizes fines. For a non laminated formation with well sorted grains, a non gravel pack completion is generaly considered adequate, unless a completion longevity is required, or the well is producing at a high flow rate. The recent advances allow the folowing options for lateral completions of consolidated formations:

- Open hole
- Pre-drilled or sloted liner
- Pre-drilled or sloted liner with external casing packers
- Casing or lajner, cemented and perforated
- Open hole with the pre-drilled liner and the stand alone screen
- Open hole with the stand alone screen
- Open hole with the gravel pack

Open hole

The open hole completion (Fig. 5) is used for stable consolidated formations that will not collapse when the well is put on production. Water and gas coning tendencies should be studied carefully since this completion design allows no contigency for shutting off unanticipated water or gas production.

Pre-driled or sloted liner

The sloted liner (Fig. 6) is generaly used when there is a doubt about the wellbore stability, or when there is some concern about the sand production. The slotted or perforated liners are those where the liner is run in the open hole and hung off in the production casing. In additon, if reactive shales have been encountered in the formation, a liner may be the adeguate alternative to prevent the hole sloughing and wellbore collapse. In well consolidated formations, pre-drilled liners are generaly used instead of the slotted liner. The sloted and pre-perforated liner completions are considered only when a little or no stimulation is anticipated and there is no concern for excluding unwanted fluids such as water or gas.

Pre-driled or sloted liner with external casing packers

The external casing packers are normaly used to provide an effective annular seal between zones of varying fluid types or pressures in uncemented open hole completions. This completion method (Fig. 7) is an improvement of the liner completion when the zone isolation is required. External casing packers are run as an integral part of the liner and after inflation they seal against the inner diameter of the borehole. They can be inflated with water, mud or cement. When properly inflated, they can provide a positive seal for the selective production, stimulation or other injection purposes. The external casing packers are used in conjuction with slotted liners, screens, pre-packed screens or liner and sliding sleeves.

Casing or lajner, cemented and perforated

The cased hole completions (Fig. 8) are defined as a liner or casing being cemented in place with perforations shut in the production intervals. Compared to the other completion methods, the cased hole completion provides a highest degree of the wellbore control and the reservoir management. Because of the possibility of cement invasion in naturally fractured formations, the cased hole completion method has primarily been used in non naturally fractured reservoirs. Cased hole completions are excellent for reservoirs where the horizontal well is being drilled to minimize coning problems. Perforations may be selectively squeezed off to prevent the influx of unwanted fluids.

Open hole with the pre-drilled liner and the stand alone screen

An open hole completion with the stand alone screen (Fig. 9) is generally used in unconsolidated formations where the sand control presents a problem. The screens are used without a gravel packing to exclude the entry of formation sand into the flow stream. The completion can be executed with external casing packers to isolate unwanted fluids, if this situation exists. Stand alone screens can be either pre packed or all metallic. The pre packed screens are actually modular gravel packs because they have a resin coated gravel or a loose sand packed around them to prevent a formation of sand passage. Pre packed screens are considered suitable for the use in horizontal wells without a gravel pack. However, the reservoir should be relatively clean, while the formation sand needs to be quite uniform, preferably not fine grained and with average volumetric flow rates.

Open hole with the stand alone screen

An open hole completion with the stand alone screen enhances the placement of the screen because it is run inside the pre-perforated liner. This technique (Fig. 10) is used primarily in unconsolidated rock, requiring sand control for which difficulties are experienced with running the screens by themselves because of well instability due to reactive shales.

Open hole with gravel pack

The open hole gravel packs (Fig. 11) consist of performing a horizontal gravel pack across the open hole interval. Advantages of this spprouch approach are the productivity maintenance and the completion longevity when compared to the stand alone screen completions. The main requirement for a successful horizontal gravel pack is a clean, stable, and undamaged well prior to running the gravel pack screen. The presence of reactive shales which swell or slough into the hole before or during the gravel packing operation is a major difficulty of the open hole gravel packing. An unstable, dirty wellbore contaminates the gravel, causing a poor well productivity.

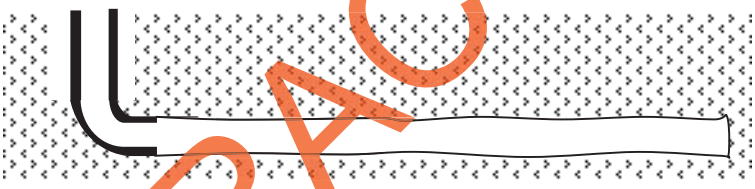

Fig. 5. Open hole.

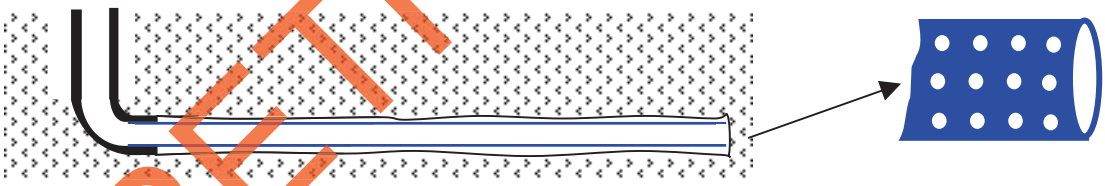

Fig. 6. Pre-drilled or sloted liner.

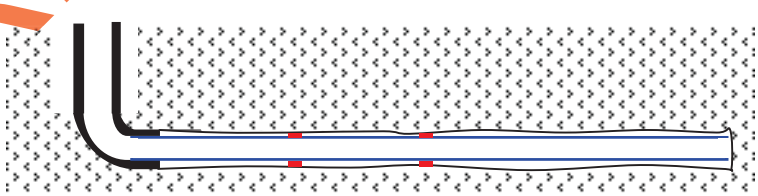

Fig. 7. Pre-driled or sloted liner with the external casing packers.

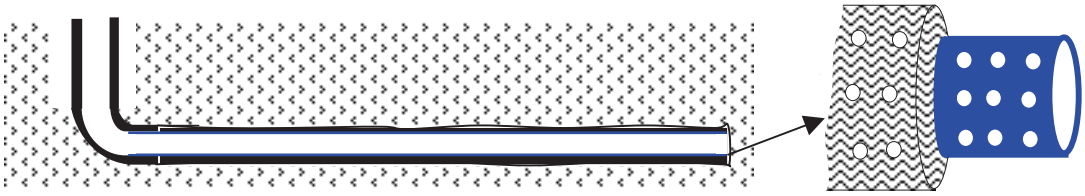

Fig. 8. Casing or lajner, cemented and perforated

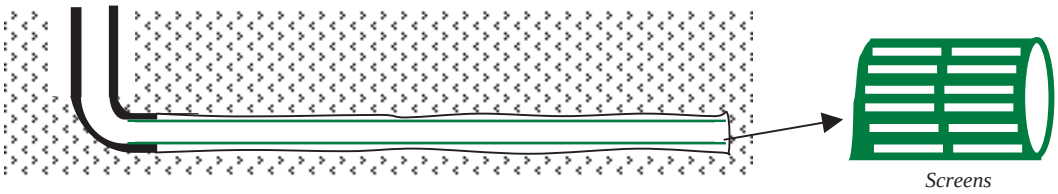

Fig. 9. Open hole with the pre-drilled liner and the stand alone screen.

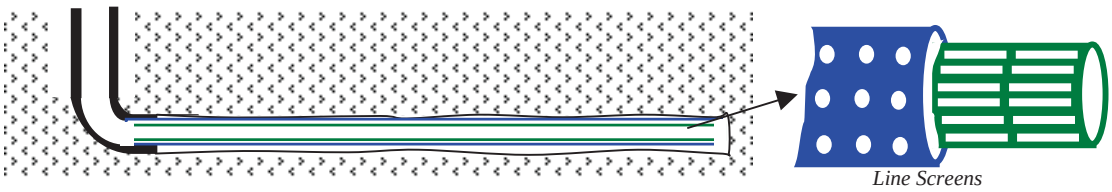

Fig. 10. Open hole with the stand alone screen.

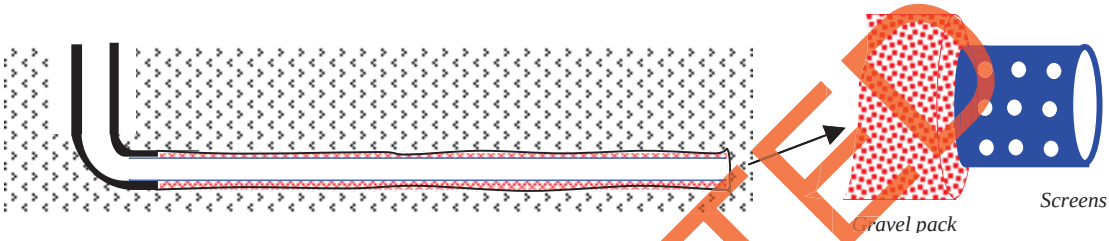

Fig. 11. Open hole with the gravel pack.

The algorithm of the horizontal well completion selection model is presented in Figure 12.

This algorithm is made on the base of an analysis of large number of wells considering the reservoir characteristics and the production constraints. It is divided, in general, in two decision trees concerning a stable or an unstable formation.

If the stable formation is considered, where there is no need for the sand control, an open hole with the predrilled liner is used. Generally speaking, the liner can be installed during the well drilling or after.By further analysis, it is checked the sand production can be expected in the future.If so it is necessary to install the pre drilled liner. The problem of possible water and/or gas coning is considered further and if there is not any, the open hole completion is recommended. If it is necessary to isolate specific zones in the well beside the precise production control, casing or liner, the cemented and perforated should be used. Instead of that completion method, the pre drilled liner or slotted liner with external casing packers can be applied.

If the unstable formation is considered too, at first should be checked the necessity of the sand control. If there is no need for that, the liner is installed during the horizontal well drilling. If there is a problem with the sand production, it is necessary to check the formation zonation. Besides additional considerations that include the duration of well working, the well productivity, the possible water or/and gas coning, there are three basic methods for the completion (presented in flowchart): the open hole with stand alone screens; the open hole with the pre drilled liner and the stand alone screens and the open hole gravel pack.

Conclusion

The completion of horizontal wells can be done by different ways and it depends on the production constraints and the reservoir characteristics. The selection of completion method is directly influenced by the degree of rock consolidation, the need for water or gas shut off, the anticipated flow rate, the completion longevity, the shale reactivity and a stability, the sand production, the degree of grain sorting and the lamination. In this article are shown the possible methods for the horizontal well completion such as: the open hole; the pre-driled or sloted liner; the sloted liner with external casing packers; the casing or lajner, the cemented and perforated; the open hole with pre-drilled liner and stand alone screen; the open hole with stand alone screen and open hole with gravel pack.

Also, it is presented the algorithm of thehorizontal well completion selection model. This algorithm is made on the basis of a large number of wells' analysis, considering the reservoir characteristics and the production constraints.

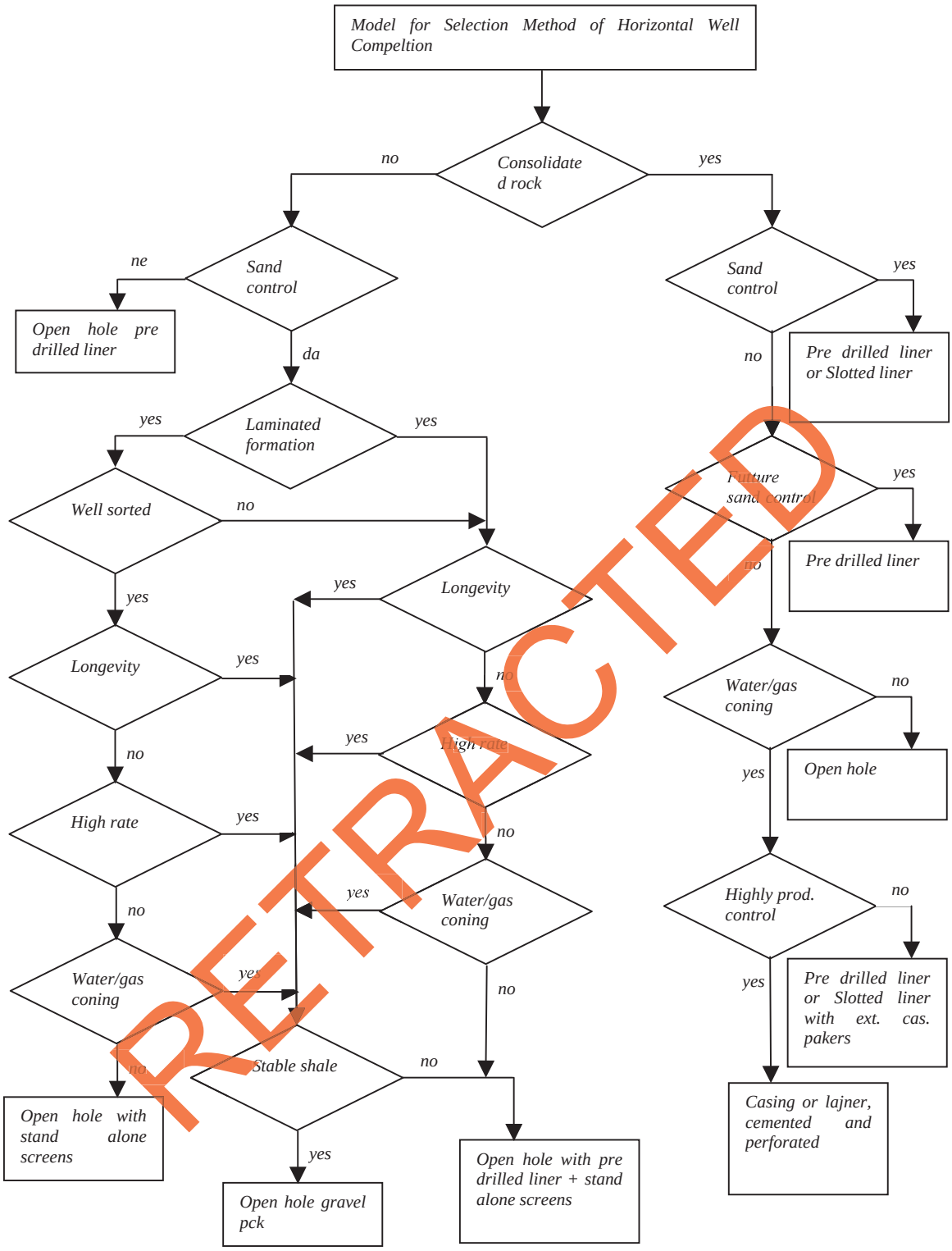

Fig. 12. Flowchart of the horizontal well completion selection.

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