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Comparison Different Techniques of Optimum Location for Infill Well Drilling

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Abstract

Increasing oil production from a reservoir can be achieved by decreasing the distance between the injector and the producer through a process known as infill drilling, which involves a pattern water flood. The main objective of this study is to provide a comprehensive overview of the optimal infill well location and the research and applications available to enhance the oil recovery factor, leading to increased economic profits. one effective empirical approach used in this study is based on decline curve analysis, which analyzes the production history of the well to determine the final economic recovery. Additionally, a numerical method that combines numerical simulation and optimization techniques has been proven to be successful in determining optimal infill drilling locations. The research results show that the volumetric computation of oil in place is a useful method for estimating the number of infill wells needed, but it does not consider heterogeneity and continuity. On the other hand, the numerical simulation and optimization techniques can quantify the remaining mobile oil post-infill drilling and establish optimal pattern configurations for maximum recovery at their centers.

Keywords: *Infill drilling; well placement optimization; Quantifying uncertainty in infill well placement.*

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1- Introduction

Infill drilling of a pattern water flood is a frequent procedure to achieve faster production and improved recovery. In most cases, a reduction in the distance between an injector and a producer will result in a quicker rate of oil production from a reservoir because of enhanced well spacing patterns brought about by infill drilling, oil may be extracted from parts of the reservoir which would normally be overlooked as a result of water floods., as most reservoirs are [1].

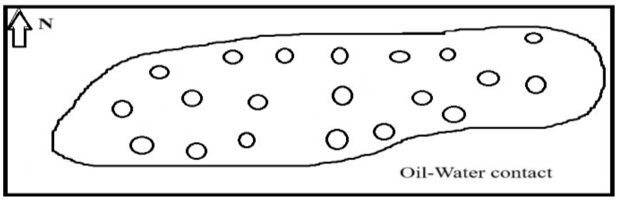
Infill drilling's performance in expanding reserves is attributable mostly to (1) effective depletion of disconnected pay and (2) better connectivity between injections and producers in restricted wells [2].

It is feasible to increase the number of wells in a selected place while also decreasing the space between them by using infill drilling. This gives employees access to portions of a field that were previously inaccessible to them [3].

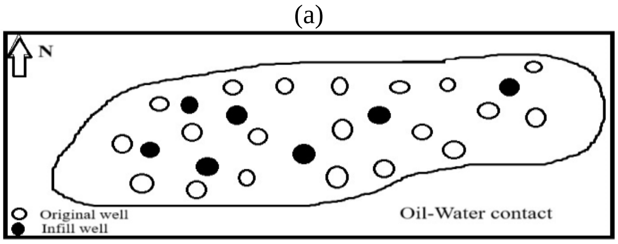
Infill drilling's performance is affected by water cut, oil viscosity, heterogeneity, and crossflow across strata. Under the right circumstances, infill drilling may confer three important benefits on a project [1]:

- A recovery that is incremental up to the economic limit.
- An increase in the rate of oil production.
- Obtained lower running costs as a result of.

When infill drilling plans are sorted by the type of field they are in, the results indicate that onshore fields are the most common. It appears that infill drilling is not commonly exploited as a viable improved hydrocarbon recovery strategy in offshore reservoirs, which may be due to the specific properties of offshore environments [4]. See Fig. 1.



(a)



(b)

Fig. 1. Infill Drilling Scenario, (a) before Infill Drilling, (b) after Infill Drilling [5]

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1.1. Factors Enhancing Oil Recovery through Infill Drilling

The greatest description of the different aspects that influence enhanced recovery during infill drilling is as follows [3, 6, 7]:

a. Enhanced areal sweep

There are two main ways that infill drilling might affect areal sweep. By promptly reversing the streamlines in the pattern, oil that is "held Up" in the corners is first swept. Second, by adding more well sites, designs that are susceptible to bad geometric alignment and resulting poor streamline balance can be greatly enhanced.

b. Areal heterogeneity Areal

In general, heterogeneity creates an injection imbalance in a pattern waterflood. As a result of this imbalance, there is an early water breakthrough and preferential sweep of only a portion of the pattern. Anisotropic (directional) permeability, distributed permeability, natural fracture system orientation, and generated vertical fractures are all examples of areal heterogeneity effects.

c. Improved vertical sweep

Additionally, there are opportunities to enhance vertical sweep during infill. In order to enhance the injection profile across different pay zones, mechanical completion processes can be assessed as producers are converted to injectors and new producers are drilled. To identify "thief zones," new producing wells can be selectively perforated.

d. Lateral pay connectivity

According to some engineers, the only contributor to incremental recovery from infilling is increased lateral pay connectivity. Driscoll reports that an investigation of the Wasson field suggests that infilling from 80 to 40 acres can result in an additional 25% floodable pay.

e. Recovery of "Wedge-edge" oil

The creation of "wedge-edge" oil as a result of formation dip at oil-water contacts or insufficient development of the pattern area infilling with smaller patterns can result in flooding of previously unflooded areas or zones.

f. Reduced economic limits

Incremental recovery as a result of improved economic restrictions is a complex topic that is heavily dependent on the operational environment of a specific field. The total operational cost per pattern may be lowered conceptually as a result of infilling. The variable operating cost per barrel produced will remain constant, while the fixed operating cost will be decreased on a pattern-by-pattern basis. Because of lower operational costs, lower oil rates or larger water cuts can be considered as the economic limit. This, in turn, leads to enhanced production and recovery at the new economic limit rather than prolonged water flooding to the previous economic limit.

1.2. Two primary methods are utilized to estimate infill possibilities

a) The first method

Empirical methodologies is used to estimate the number and spacing of infill wells depending on a volumetric estimate of the oil that is already there. It doesn't look at how continuity and diversity affect each other [8].

b) Second Method

Using numerical simulation and optimization methods is fundamental in evaluating infill well potential in the industry. Currently, most evaluations in the industry fall into one of two categories [8]. The first one is using a technique called decline curve analysis, in which a well's production history is analyzed by the operator to establish a EUR (economic ultimate recovery). The operator then calculates the volume of gas present using standard volumetric techniques. In order to drain the gas reservoir, the operator will, according to the estimated amount of gas that can be recovered from a typical gas well, decide the well space and the number of wells that will be required. A reservoir's characteristic complicated sand continuity and heterogeneity cannot be fully accounted for by such decline curve analysis because it is based on oversimplified assumptions about reservoir features. Additionally, "blanket drilling" techniques are typically used to drill infill wells, ignoring the need for infill wells in some regions while allowing for the development of other reservoir areas without the use of infill wells. The second method uses comprehensive numerical simulation research, which includes the generation of thorough geological descriptions, the upscaling of geological models, and the historical match of existing wells**.** In order to ascertain whether or not infill wells are possible; the matching wells' past is analyzed. The upscaling step commonly blends pay and non-pay, which artificially boosts sand continuity while diminishing infill benefits. This is one of the common reasons why the upscaling phase contributes to inaccurate results. In addition, smaller companies don't often use history matching because of its potential for being too difficult, time-consuming, and labor-intensive. This study uses the second technique, which involves analyzing the remaining movable oil at the period of infill drilling, to determine which pattern configurations result in the greatest amount of oil being recovered at their centers [8, 9].

The success of infill drilling is strongly connected to the uncertainty surrounding it. Total uncertainty related to reservoir performance is determined by the sum of all reservoir attributes. Due to the complexity of petroleum reservoirs, analytical models, which are governed by several assumptions, are losing their ability to accurately assess and quantify many types of uncertainty [10]. Infill drilling can boost hydrocarbon recovery by hastening hydrocarbon production [11].

However, it has been difficult to determine infill potential and choose the right well type and location [12].

1.3. Candidate Selection for Infill Drilling

In order to get the fields ready for the infill drilling, they were examined and screened. To find initial prospects for infill drilling, there are a number of different approaches to analyzing the performance of reservoirs, like numerical-reservoir-simulation models, volume balance concepts, and, in some cases, streamlined simulation. were utilized. Water-flood optimization techniques and graphs were also commonly employed. The two essential indicators for selecting infill-drilling candidates were (1) the quantity of reserves that are still available, and (2) the capacity of the water flooding pattern to accommodate farther down spacing by shifting from an inverted five-spot pattern to an inverted nine-spot pattern. Following an extensive amount of infill drilling, it was discovered that these two critical indications were insufficient for implementing a successful infill drilling program. Heterogeneity of reservoirs. It was revealed that the number of infill wells and the improvement of water-injection facilities are key influencing elements in the decision-making process for infill drilling [13, 14].

1.4. Infill Well Placement Determination and Optimization

The challenge of optimizing the placement of wells is a restricted, multimodal, and high-dimensional optimization technique (for non-trivial problems). Increasing the NPV is the primary goal of oil field development. Drilling more oil production wells in the field is one way to increase NPV, however, this strategy is extremely dependent on how many wells are drilled and where they are located [15]. At the end of the simulation, contour maps of permeability and oil saturation can be used to show where the suggested infill wells should be put. These contour maps are the better way to find the best and worst locations to drill infill wells [16]. The criteria used to generate these maps objectively evaluate the potential of each grid block in relation to the well [17]. Optimization approaches are modified to identify the ideal number and locations of infill wells after determining the potential locations for infill wells. In order to choose suitable candidate areas for the deployment of infill wells, a few restrictions are mentioned in this section. For the purpose of determining the locations of infill wells, certain limitations are set. Some of these restrictions were put in place to ensure that the wells produced could be drilled, while others were implemented to prevent developing solutions that have been shown to not work well since they could infringe standard procedures for petroleum engineering. The limitations may be simply applied to the initial population because we had control over the initialization procedure. The infill well placement problem is described by the following constraints [18-20]:

1- Total oil saturation plus the amount of oil still in the reservoir. The soil oil saturation at the place where the infill well is intended to be constructed must be more than or equal to the soil oil saturation (Soil). (Sor) and 10%. In other words, the oil saturation level in any area where an infill well is to be drilled must be at least 10% greater than the residual oil saturation. This is carried out to make sure there is enough oil to be produced from the intended location. If a location does not meet this requirement, it is taken out of the search area. The major objective is to stay away from drilling wells in places where there isn't much oil. This restriction can be written in math as Soil (Sor + 10%).

2- The average pressure at the suggested place has to be higher than the minimum pressure in the reservoir. This constraint was put in place to maintain a steady reservoir pressure in the grid block where the infill well would be located was greater than the reservoir's cutoff pressure and therefore adequate to produce the oil.

3- We will be situated distant from the aquifer, faults, borders, and oil-water interaction. There are two different kinds of boundaries: an aquifer and a no-flow border. The flow is always perpendicular to the no-flow barrier. In order to prevent water coming and excessive water cuts, Wells cannot be placed in close proximity to faults or no-flow boundaries thanks to the boundary condition limitation on good installation. All candidate locations near faults, aquifers, and the original population is cleaned of oil-water contacts (OWC). and the list of possible places to drill an infill well.

4- Wells will be placed on moving blocks. All possible infill well placements can only be accommodated by the reservoir model's active blocks as not identical for this analysis, wells will be clustered in the same grid block, and preexisting wells will be removed. Fig. 2. Integration between optimization and reservoir simulation [21].

2- Previous Studies

Many studies have looked at various aspects of well-site optimization, including numerical techniques that use numerical simulation mixed with optimization algorithms and empirical methods that are focused on decline curve analysis.

Emmett et al. Results showed that decreasing well spacing from 40 to 20 acres increased final recovery and accelerated production. Nevertheless, no valid data were gathered to associate waterflooding with well spacing. As a result, well spacing and pattern analysis is required for infill well drilling in waterflood systems [5].

Yadavalli et al. Waterflood infill drilling efficiency was evaluated in Ector County, West Texas's Johnson J.L. "AB" unit. An economic study of the two infill drilling options shows that the focused infill drilling model gave higher recovered and good financial yield than the case of

blanketed infill drilling. The best infill drilling design, they discovered, didn't even have to adhere to any particular pattern at all.
[20].

Fuller et al. The Predictive Model for Infill Drilling (IDPM), which requires only a basic understanding of geology and reservoir, has also been employed. However, IDPM necessitates an understanding of heterogeneity components, such as layer permeability variation and pay continuity, which are difficult or infrequently quantified in actual fields [5].

Stiles, L.H. New techniques included a simplified waterflood model and a statistical approach to measure reservoir continuity. Evaluation of alternate plans with these tools indicated the plans with these tools indicated the need for infill drilling and a closer-spaced pattern [21].

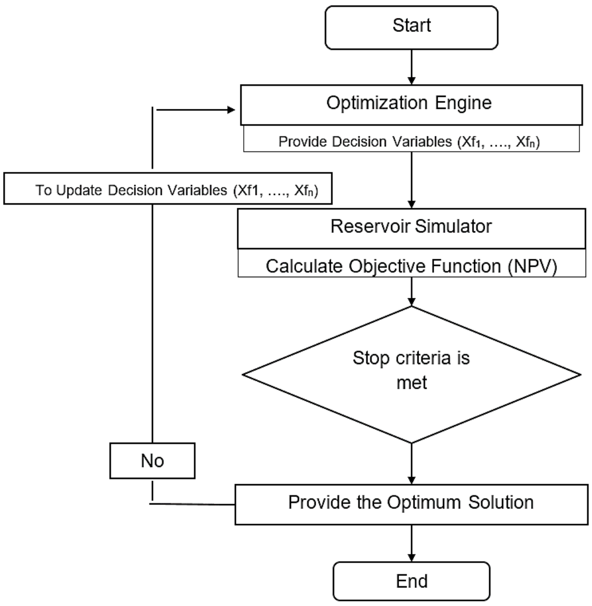

Fig. 2. Integration between Optimization and Reservoir Simulation

Voneiff and Cipolla. The moving window methodology, a model-based analysis method, was created and used to quickly assess the infill and re-completion potential in the Ozona field. The author claims that while the procedure is quick, accuracy declines as heterogeneity rises [22]

Wences et al. economic analysis (net present value, mobile saturation calculation, the ideal number of extra wells drilled and their locations, compared with primary, secondary, and EOR processes) is used to direct the activities of a reservoir modeling group to determine the best plan to optimize recovery (which could be waterflooding, gas injection or WAG). Using this method significantly reduced both the level of uncertainty and the number of sensitivity analyses that were needed [23].

Singhal et al. economic analysis (net present value, mobile saturation calculation, the ideal number of extra wells drilled and their locations, compared with primary, secondary, and EOR processes) is used to direct the activities of a reservoir modeling group to determine the best plan to optimize recovery (which could be waterflooding, gas injection or WAG). Using this method significantly reduced both the level of uncertainty and the number of sensitivity analyses that were needed [24].

Wathiq and Mohammed. Using this theory in the case of infill oil well placements, we looked at the possibility of optimizing these operations on a field scale. This was done in order to identify the most promising well locations, which is essential for planning the future of the field. South Rumaila, an oil field in Iraq, was modeled and optimized for its sandstone formation [25].

Hudson et al. The infill potential of a complicated, low-permeability gas reservoir may be calculated using both theoretical models and empirical correlations. As these connections are reservoir-specific, their usefulness is restricted [26].

Obed. evaluated the placement of the infill wells using the particle swarm technique. By determining the best well placements and assessing how the number of infill wells and well spacing affected the final recovery of a synthetic model, the research attempted to resolve the problem of good placement [27].

Gao and McVay. on challenges of a large scale and medium resolution, and they proposed a simulation-based inversion approach as a means of doing a speedy assessment of the potential of infill wells. They employed a single reality for prediction and infill well selection while using the inversion approach to match the history. They made a prediction based on the wells that were already there and then built an infill well for each grid block. estimating the incremental output of the field at the conclusion of this procedure, they choose the location that offers the highest new output from existing fields. However, they did not solve the issue of interference between new infill developments. in their response [28].

3- Conclusions

The analysis and results presented in this study present the following conclusions:

a) Infill drilling has been proven as an effective method of increasing reserves in several reservoirs by decreasing the space between the wells and extracting more residual oil saturation from the reservoir.

b) The level of reservoir homogeneity can be used to predict incremental reserves resulting from infill drilling.

c) Reservoir heterogeneity is the most relevant factor for determining the value of infill drilling.

d) The successful depletion of disconnected pay zones and the improvement of connectivity between injectors and producers in narrow strata are the primary reasons for the success of infill drilling in expanding reserves.

e) The efficiency of infill drilling in increasing reserves is influenced by a variety of factors, including the number of infill wells, the ability of field operations to inject sterile water, and continuous efforts to improve the capabilities of the water-injection systems to meet target rates.

Nomenclature

NPV Net present value
WOC Water oil contact
ANN Annealing -Neural- Network
Sor Residual oil saturation
EUR Economic ultimate recovery
IDPM Infill Drilling Predictive Model
PSA Particle swarm algorithm

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مقارنة التقنيات المختلفة للموقع الأمثل لحفر الآبار

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الخلاصة

يعد الحفر بالملء لأنماط الغمر المائي ممارسة شائعة لتحقيق تسريع في الإنتاج وتحسين معامل الاستخلاص الذي سوف يعجل انتاج النفط من المكمن لتقليل المسافة بين ابار الحقن والإنتاج. الهدف الرئيسي من هذه الدراسة هو اظهار دراسة شاملة لأفضل موقع لأبار الملء والبحوث المتوفرة والتطبيقات المتاحة لتوظيف هذه التقنية لتعزيز عامل الاستخلاص النفطي وبالتالي تحقيق عوائد اقتصادية. التقنيات المستخدمة لإيجاد افضل مواقع لأبار الملء تتضمن تقنيات تجريبية التي تعتمد على تحليل منحني الانحدار حيث يستخدم سجل انتاج البئر لتحديد الانتعاش الاقتصادي النهائي، علاوة على ذلك التقنية الرقمية التي تعتمد على المحاكاة العددية المقترنة بخوارزميات التحسين. اخيرا, توضح النتائج التي تم الحصول عليها من هذه الدراسة ان التقنية الأولى تحدد اعداد ابار الردم والتباعد بناء على حساب حجمي للنفط في المكان الي يهمل تأثير عدم التجانس والاستمرارية، بينما تحدد النتيجة الأخرى التي تم الحصول عليها من التقنية الثانية النفط المتبقي في وقت حفر الملء وتحديد تكوينات الأنماط المثلى التي تتمتع مراكزها بأقصى قدر من الاسترداد.

الكلمات الدالة: حفر الردم، تحسين وضع الآبار، قياس عدم اليقين في وضع بئر الردم.