The Importance Of Infill Drilling In A Mature Offshore Field

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Abstract

Infill drilling is commonly used in a mature offshore field to achieve accelerated production improved recovery. Generally, infill drilling can improve oil recovery via sweeping unswept zones, and by improving areal and vertical sweep, thus will improve the economic limit.

Introduction

The petroleum industry has conducted extensive research on enhanced oil recovery since 1930's most of those processes developed are designed to recover the oil left in a reservoir after waterfloodi following other conventional secondary processes. But there is a number of petroleum engineers believe that the most efficient method of improving ultimate oil recovery is merely to drill more v Infill drilling, however, can be considered feasible and successful as long as the amount of increment produced covers the cost of the extra wells and associated pipeworks, at small financial risk.

Background of Infill Drilling

Generally, if size of investment is the criterion used to obtain world prices, then modern drilling programs may meet this requirement. Infill drilling which is always combined with water-flo in order to maintain pressure at or above saturation pressure, if it is done properly such as under reservoir engineering practices, can be used to recover at least as much oil as the U.S. has already prod a controversial statement that still goes on today. There was a statement saying that infill drilling is a effective way of improving oil recovery than tertiary or enhanced oil recovery using chemical su carbon dioxide, surfactant, polymer etc because there were claims made such as tertiary recovery metho too expensive, too slow in developing and of questionable utility.[1]

The National Petroleum Council published a study on EOR potential in the U.S.,[2] saying t crude price is at US$20/bbl and below, infill drilling would appear to have potential equal to or greate EOR.

Infill drilling performance is sensitive to water cut at infill, reservoir heterogeneity, oil vis and the degree of crossflow between layers. Thus several factors must be considered during planning infill project:-

- Production of injection performance
- Reservoir description
- Infill drilling project design, and
- Economic evaluation

If any one of these factors is analysed insufficiently, the project could fail.[3]

The Advantage of Infill Drilling

Both the acceleration and incremental recovery benefits from infill drilling have been the subjects of heated discussion, in terms of their potential impact on reserve development and national production, and also the desirability of tertiary EOR projects if the incremental recovery from the infilling is economic.

Typically, an increase on the order of four percent of the stock tank oil originally in place (STOIIP) can be obtained by infill drilling from 40 to 20-acre spacing. However this can vary by a factor of two or more depending upon the specific situation.[4]

Generally there are many advantages can be realised from infill drilling in a mature offshore field, and most of these factors are related to various reservoir heterogeneities which are quantitatively more important in fluid injection projects.

Areal Sweep Improvement

The process of infilling gives two major effects on the areal sweep and there are:-

- o "Held-up" oil in the corners is immediately swept by reversing the streamlines within pattern, and
- o Patterns which are subjected to poor geometric alignment and resulting poor streamline balance, can be improved significantly with additional well locations.[4]

Taking Full Advantage of Areal Heterogeneity

One of the factors that can make a large difference in waterflood recovery is the presence of adverse areal heterogeneity, which can be caused by natural or induced fractures, anisotropic permeability etc. Areal heterogeneity causes injection imbalance in a pattern waterflood, thus resulting in early water breakthrough and preferentially sweeping only part or the pattern.

Undetected pockets of high oil saturation which are due to the areal variations of permeability and porosity, can be swept when the streamlines are reversed after infill drilling. Nevertheless, the degree of incremental recovery depends totally on the reservoirs geologic description. Determining the areal variation of oil saturation or permeability is very difficult but important if a proper infill design is to be made.[4]

Recovery of "Wedge - Edge" Oil

The presence of wedge-edge oil might be due to the inadequate edge development, uneven lateral extent of pay zones, and dipping of the various porous zones and the presence of oil-water or gas-oil contacts. Infilling with smaller patterns can result in more oil be swept near the oil-water contact or stratigrafic features.[4] In some fields originally developed on wide spacing, this can result in signicant oil recovery.

Lateral Pay Connectivity

Many engineers believe that infill drilling can improve lateral pay connectivity, which in turn will increase ultimate recovery. An analysis of the Wasson field showed that an additional four percent floodable pay was achieved by infilling from 80 to 40 acres, as a result of minimising lateral pay discontinuities.[4]

Figure 1.0 depicts the performance of the Raja field after the primary infill project which showed that more than a 10 fold increase in production caused primarily by lateral continuity effects.[5]

Vertical Sweep Improvement

An opportunity exists during the infill process to isolate previously swept zones mechanically to maximise vertical sweep, since producers can be converted to injectors whilst new producers can be drilled in order to improve the injection profile amongst various pay zones. Nevertheless, the effectiveness of this program depends on the degree of crossflow between the new active zones and the isolated one such as the thief zone.[6] Generally, vertical sweep improvement will lead to better control of injection profiles.

It is very important to ensure that all pay is taking water during the waterflood operations. Thus acid interface technique might be required in order to successfully establish injection in porous sections which were not producing fluids, not previously taking water or production from porous sections.

Confining Injection Fluids to Pay Zones

Problems such as the wells which are found to be losing significant amount of water below the total depth of the wells when they are converted to injectors (due to heavy stimulation in the past), the presence of vertical fractures in the dense zones resulted from the high rate, high volume fracture treatments, may result in effective elimination of communication to an underlying or overlying water bearing zones (see Figure 2.0).

Generally, these problems cannot be solved by remedial techniques such as the selective plugging, squeeze cementing and others in an effective manner. Thus infill drilling is often required to provide for more effective alleviation of these problems.[4]

Oil Shrinkage Reduction and Displacement Improvement Via Accelerated Flooding

Gas can be re-dissolved in the solution via accelerated water injection, which will slightly reduce the oil viscosity. This phenomenon will furnish minor improvement in mobility ratio which in turn will improve displacement, vertical and areal sweep efficiency.

For example, the Levelland (San Andres) unit indicated that an additional 0.44 percent of STOIIP could be recovered for each 100 psi higher, pressure at which flooding occured in the intermediate primary depletion range.[7]

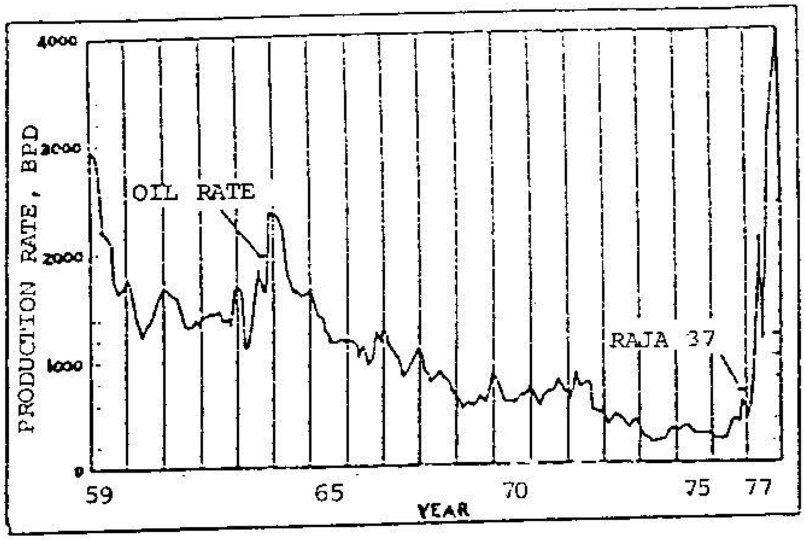

FIGURE 1.0

RAJA PRODUCTION AFTER INFILL DRILLING

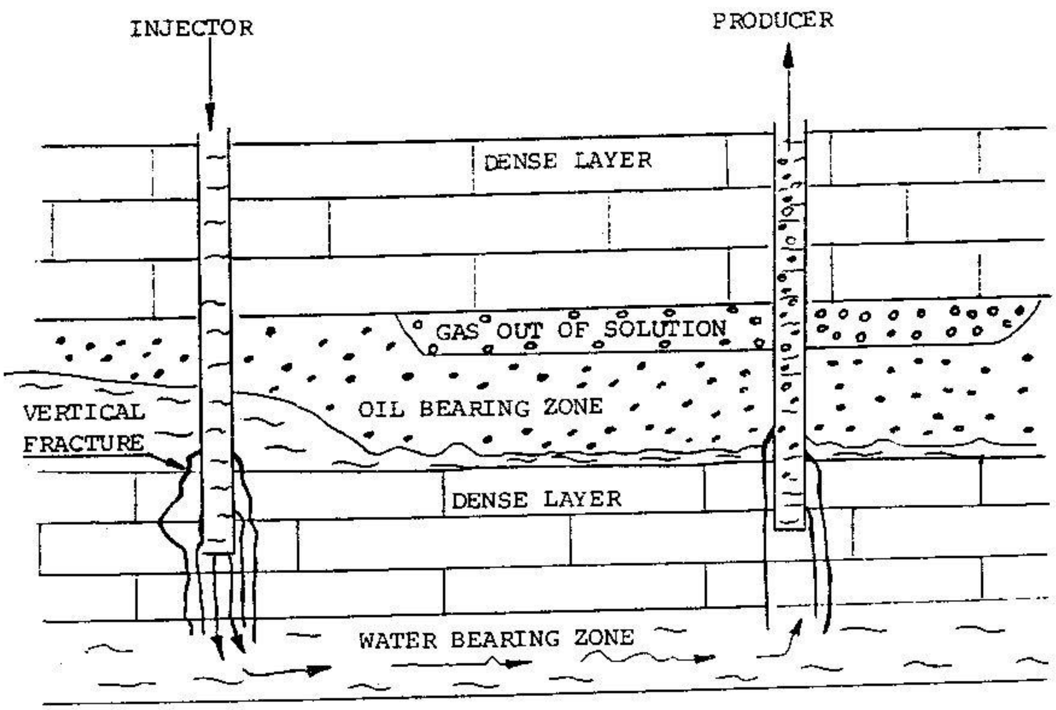

FIGURE 2.0

CONFINE INJECTION FLUIDS TO PAY ZONES

Increasing the Conductivity/Rate via Infill Drilling

With closer spacing, infill drilling is believed to have the capability of increasing recove because the resistance to flow is reduced significantly.

Driscol[4] found that the geometric conductance ratio of an 80-acre five-spot over a 40-acre five-spot for the same 33.8 ft effective wellbore was about 1.125. Thus with doubled density, it was found that the injection and producing rates after filling-up were on the order of 2.25 times th 80-acre flood rate for the same condition such as stage of depletion, same pressure differential, etc

Time - Saving Project

One of the major factor in determining the successful of an offshore operation is the tim required to complete a particular project in a competent manner, because the associated costs involved are always closely related to the time used.

Infill drilling programs are less expensive because no chemicals or compression costs required, and also it will not be delayed by chemical acquisition of injection plant construction.

Better Performance When Combined With EOR

The combination of infill drilling and EOR in the same project can be very effective. Restine et al.[8] reported that an incremental oil recovery of 4 to 7% was realised, when a tertiary steamflood process was followed by an infill drilling project.

Generally, it is recommended to perform infill drilling before a tertiary miscible or chemical process because it has the benefits of better pattern control, shorter project life (thus be rate of return) and improved areal or vertical sweep. For instance, the incremental recovery achie by the infill wells may be more than sufficient to pay out these wells before the tertiary project. On top of that, the essential tertiary recovery projects will have closer-spaced patterns in place.

Improved Economic Limit

One of the significant advantages of infill drilling is the acceleration of the recovery. In addition to increasing the number of producers, the field injection rate is also increased by more th the well ratio might indicate because the pressure drop between injector and producer occurs over short distance. As a result of these changes, the economic for a project may improve

Conclusions

1. Infill drilling provides incremental recovery in addition to the acceleration of production, thus improve the economic limit.

2. Incremental recovery can be obtained primarily by sweeping unswept areas and also by improv the vertical and areal sweep.

3. Reservoir which gives relatively poor initial waterflood efficiency on less dense spacings should be analysed as candidates for incremental recovery by infill drilling. But there are no infill projects without risk, thus detailed reservoir description and appropriate infill project design are required in order to improve the chances for success.

4. Combining infill drilling with EOR projects as either a prephase or post-phase can result in substantial increase in oil production and oil reserves.

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