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Challenges and Opportunities - Mature Oil Fields

Gaurav Goswami
Project Quality Manager (Oil & Gas), Houston, Texas, USA.

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Abstract: *Recent reports project that global population will increase by 2 billion and worldwide energy demand will increase 38% by 2040. Energy is very important to meet basic needs and to improve living standards of people. Increasing population, urbanization, and efforts to improve living standards worldwide are driving rising demand for energy. About 70% of the oil produced today comes from mature fields. The average recovery factor is 35% and some oil fields produce even less due to geological characteristics, fluid properties, resource constraints, or operational inefficiencies from old technology. Mature oil fields matter today more than ever because regulatory bodies are appearing more and more unreceptive toward abandoning producing wells too early so now, we need to look for new technologies to increase production from mature oil wells to sustain economic viability and minimize global warming challenges. Increasing recovery from mature oil fields by just percentage-point could add two years to the global hydrocarbon supply. Brief overviews of challenges and opportunities in mature oil fields are presented in this paper.*

Keywords: *Mature Oil Fields, Remaining Oil, Tertiary Oil Recovery, Well Optimization, Enhance Oil Recovery*

I.INTRODUCTION

Worldwide energy demand is increasing day by day and worldwide energy consumption projected to increase by more than 38 percent by 2040. Most of the world's oil production comes from mature fields and increasing production from these mature fields is a major challenge for the Exploration & Production (E&P) companies. No matter what kind of recovery mechanism, there are always significant portion of oil, always higher than 60% of original oil in place, unrecovered in mature oil fields.

A field is considered "mature" after a certain production period. There are many definitions for "mature" field. Engineers consider fields mature when they have declined in production by more than 50%. An oil field can be classified as mature when its production rate is significantly declining and/or when it is close to reaching its economic limit. A field might also be considered mature when it is close to attaining a recovery factor considered acceptable for its reservoir mechanisms. Typically, a mature field will have very old wells and aged equipment and infrastructure which have a higher risk of safety and environmental issues.

The constantly increasing demand for petroleum products and the increasing difficulty of finding new oil fields is directing serious attention to the oil left in the ground at the time when wells producing by normal methods have approached their economic limit. To tap the potential of mature oil fields has become a strategic topic in the industry. Increasing ultimate recovery of these fields will extend the peak production period of the field or flattening the decline curve itself through secondary and tertiary methods. New technologies need to be employed to minimize production decline rate from these mature fields.

This paper presents the basic concept of improving production from a mature oil field. The basic concept to increase oil production from mature oil field is to identify challenges and solutions to overcome these challenges. Application of this basic concept not only improve the production but also at lower cost compared to additional oil from new drilling from mature fields.

Maximize recovery is the goal in any mature field. In the past, operators shifted resources elsewhere once the "easy oil" was found and produced. With advances in new technology, getting as much as possible from existing assets is becoming more and more feasible.

II.OIL RECOVERY

Every producing reservoir has a life cycle. In the start of production life, an individual oil well usually produces at its maximum rate, but production rate eventually declines to a point at which it no longer produces profitable amounts.

Primary Recovery:

This phase is characterized by the recovery of hydrocarbons from the reservoir's natural pressure. This is the result of several physical mechanisms that combined create what is called the reservoir drive. One of the mechanisms of the reservoir drive is the natural water drive, which displaces the oil upward in the well. Other mechanisms are the gas-cap drive, which expands the natural gas at the top of the reservoir and displaces the oil downwards towards the producing well.

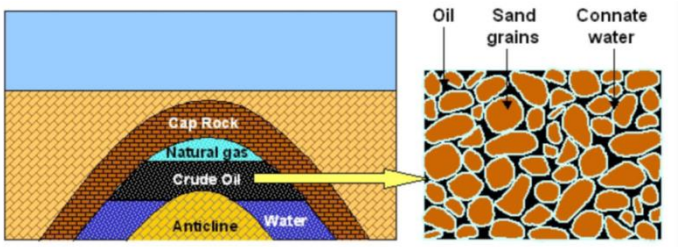

Figure 1: An example of an oil and gas reservoir, Source [6].

The primary oil recovery efficiency typically ranges from 10% to 25% of original oil in place and it depends on geological characteristics and the fluid properties. Primary recovery period is marked by a high volume of production that declines relatively quickly

Secondary Recovery:

Secondary oil recovery methods are applied when primary oil recovery methods are no longer profitable. This phase includes the use of basic techniques such as injecting water into the reservoir or using artificial lifts to generate additional hydrocarbon flow and manage pressure.

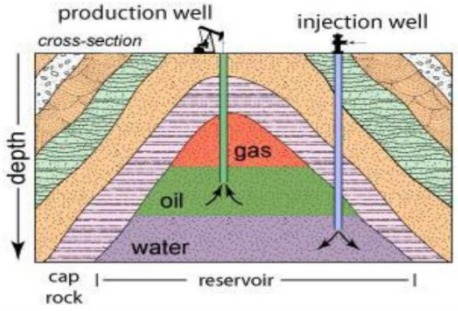

Figure 2: The principle of secondary oil recovery, Source [6].

The additional amount of oil recovered in secondary recovery phase depends on the characteristics of the reservoir and the properties of the petroleum fluids, but it is suggested that an additional 10-20% of original oil in place may be recovered.

Tertiary Recovery:

Tertiary recovery also called Enhanced Oil Recovery (EOR). This phase increases the sweep factors of the reservoir by drilling and completing smart infill wells, revamping facilities, redesigning water flood schemes and using advance technologies. Additional recovery in this phase depends on the application of available new technologies to make it economically viable and reservoir management strategies.

III.CHALLENGES

Extracting oil from mature fields presents specific challenges. The main challenges in the mature field are:

- Low reservoir pressures and rapid decline in oil.
- Flow assurance problems.
- Large well spacing.
- Down hole scale formation: The most common problem of a mature wellbore is damage caused by scale, or paraffin build-up.
- Non-productive wells and old infrastructure.
- Existing wellbores and sidetracks that challenge well planners.

IV.OPPORTUNITIES

By using new technologies, it is possible to recover crude oil previously considered too tightly bound to the reservoir rock to be extracted in a profitable way.

Water Flooding:

Water is injected into the reservoir to increase reservoir pressure and thereby stimulate oil production.
Water flooding is the most successful method for recovering oil from reservoirs due to following reason:

- Water is efficient in displacing oil of light to medium gravity;
- Water is fairly easy to inject into oil-bearing formations;
- Water is cheap and readily available;
- Water flooding requires lower capital investment and operating cost, which makes it more economical.

Artificial lift:

Artificial lifts can reduce back pressure on the well by boosting the untreated well flow, and by allowing the reservoir to

accelerate production and the operator to delay abandoning a producing well. Gas lift is a well-known form of artificial lift which is used to improve oil production. When high pressure gas injected in the annulus between tubing and casing through one or more subsurface valves at predetermined depth. The gas will then reduce the weight of the produced fluid column, which will lower the bottom-hole pressure. Reservoir fluid will then experience lower resistance to flow, resulting in increased flow rates and increased production. Artificial lifts widely used to improve oil production and improving the efficiency of the artificial lift system have great impact on lifting cost.

Infill Wells:

If there are significant reserves remaining, infill wells including horizontal well drilling or side tracking could be the solution, however a detailed geology study should be performed for identification of any infill drilling locations.

Horizontal drilling in mature oil fields is an attractive option to enhance oil production. Additional oil recovery demonstrates economic viability of the horizontal drilling.

When reservoir analysis reveals opportunities for infill drilling, reservoir engineers need to determine the proper well density and determine the best location of infill wells to reach areas of high oil saturation and place wells in the context of existing offset well path data.

Polymer Flooding:

For mature oil fields, even after successful secondary recovery, there is always about 50% to 60% of oil original in place remaining in reservoirs. Chemical injection could be one of the solutions to increase production form mature oil field. The chemical could be surfactant, polymers, or other chemicals.

Scale Removal:

Scale formation occurs when a supersaturated regime is established. If scale is left untreated then it can block oil wells. Because of their properties, organic deposits tend to become more critical as reservoirs mature and as production rates decrease. Scale needs to be removed to increase the production.

Scale can be removed by using following methods:

Chemical Removal: Chemical scale removal is usually a cheap and easy way to remove scales, but the effectiveness of the removal depends on surface to volume ratio of the scale.

Mechanical removal: There are many ways of removing scales mechanically.

- Milling or impact techniques.
- Explosives induce shock vibrations.
- Jet blasting techniques.

V.REVITALIZING MATURE OIL FIELDS

There are several methodologies and technologies available to revitalize mature oil fields. However, before selecting which one will be used, it is necessary to assess what is the “target prize” of your revitalization project.

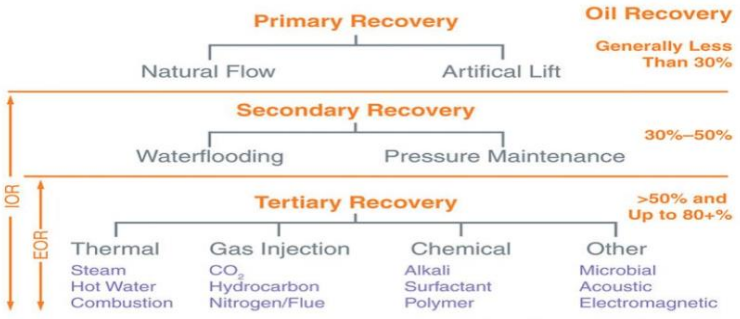

Figure 3: Defining improved oil recovery (IOR) and enhanced oil recovery (EOR), Source- [10].

Following steps need to be followed to select methodology / technology for revitalizing mature oil fields:

- Prepare an integrated reservoir study to identify the hydrocarbons initially in place, in all zones,
- Develop an understanding of the remaining hydrocarbons in each zone based on the current field-development plan.
- Review development strategies and technologies used by other companies elsewhere in the world.
- Test the strategies and technologies using a reservoir simulation model and assess their potential economics.

VI.CONCLUSION

Based on the above study, the following conclusions could be made:

- New technologies are allowing greater percentages of hydrocarbon to be produced economically.
- Horizontal infill wells are often considered as the best way to enhance oil recovery.

- Injection of gas, steam, or chemicals are being successfully employed to give new life to mature oil fields.
- Top management need to take bold investment decisions.
- Mature fields require more careful planning, especially during the reassessment phase, to identify producible reserves that were previously missed or thought unobtainable.
- Applying the correct methods and technologies is key in redefining the value of these hidden assets.

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