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RESEARCH ARTICLE

INCREASING THE PRODUCTION OF MESSLA OIL FIELD, SIRTE BASIN-LIBYA

*Alfageh, Z. A.

Department of Petroleum Engineering, Faculty of Engineering, University of Benghazi, Benghazi Libya

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Corresponding author:
Alfageh, Z. A.

ABSTRACT

The Messla oil field in Sirte basin consist of 54 production wells covering 52.591 acres. The reservoir of interest contain light oil and primary production is estimated to account for 45% of the original oil in place (OOIP) 3.075 billion barrels (BBL). The Messla oil field is operated by National Oil Corporation (NOC) subsidiary Arabian Gulf Oil Company (AGOCO). Due to the hard economic situation which our country lives in. It is essential to the economy to produce as much oil as physically possible, to save the economic from collapse. There are two options that can be implemented in the field to increase production: water flooding and steam flooding. Both options are favorable under specific criteria. Experiences of worldwide Improved Oil Recovery (IOR) projects and papers have been reviewed for geological characteristics, cost and equipment information for water flooding and steam flooding.

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INTRODUCTION

The Messla oil field is located in Concessions 65 and 80 in Sirte Basin (Fig. 1). The field's production is obtained from the basal Cretaceous fluvial Sarir sandstone (1),(2), which lies unconformably on basement and capped by a thick sequence of upper Cretaceous Rakb shales(3). The reservoir consists of two sandstone units (Upper and Lower Sarir), separated by a continuous shale bed (Red shale) (4). The field was discovered in October 1971 and commercial production since 1973, and has not been placed under a secondary recovery method. The original oil in place is 3.075 BBL and the total production from 1973 to 2013 it is about 1.355 BBL (5). With increasing demand of petroleum products combined with diminishing oil reserves, it is essential to produce the maximum amount of oil out of the reservoirs. Production can be more higher with the implementation of a secondary oil recovery method. There are two possible solutions to implement in the case of Messla oil field: *water flooding* and *steam flooding*. Implementing a water flood would increase production in the field by injecting water into the formation through injection wells and producing existing wells.

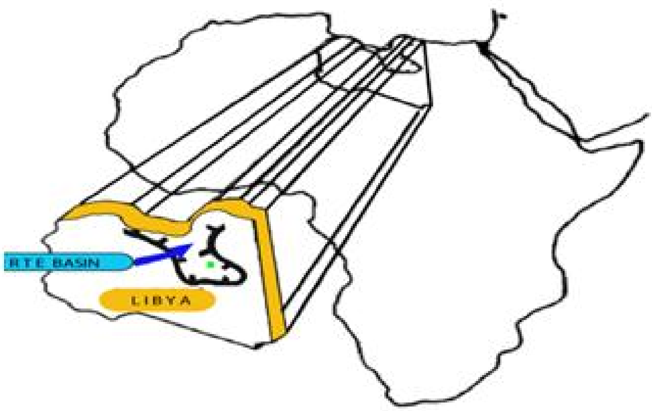


Fig. 1 Location map of the study area, green rectangle.

A steam flood would also increase production in the same manner as a water flood by injecting steam into the reservoir. Each of these solutions will be evaluated on three fundamental criteria: Geology, cost, and required equipment. The following table (Table 1) shows the geological criteria of the interest formation.

Table 1. Geological Characteristics of the reservoir under study

Average Depth to Base of Sand (ft)	8550
Average Reservoir Temperature (ºF)	235
Average Porosity (%)	17.1
Average Permeability (md)	251.9
Average Sand Thickness (ft)	85
Average Crude Oil Viscosity at Reservoir Conditions (cp)	0.79
Area (Acres)	52.591
Crude Gravity °API @ 60 ºF	36.7
Initial Oil Saturation (%)	58.6
Estimated Oil Saturation @ Start of Steamflood (%)	55
Formation Volume Factor (Res bbls/stb)	1.3
Original Oil in Place @ Start of Steamflood (MMBBL)	1.8

CRITERION DESCRIPTION

Geology: First and foremost, the geology of the reservoir must be evaluated. Water floods and steam floods are successful under specific characteristics (6). The characteristics must be evaluated are listed below:

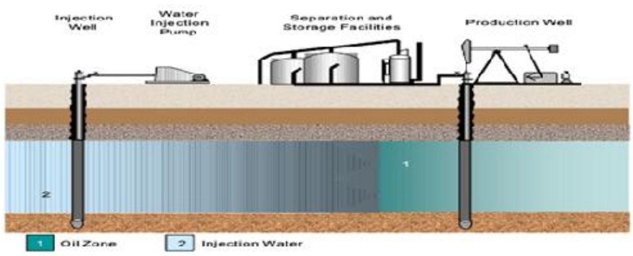
- Porosity (%)
- Permeability (md)
- Oil Gravity (˚API)
- Oil Viscosity (cp)
- Reservoir Depth (ft)
- Reservoir Thickness (ft)

Cost: The final cost is the second criterion that must be evaluated. The cost is dependent on several factors. When implementing a secondary recovery method there are two main expenses; the first is the cost of primary equipment and machinery needed to perform the task. The second is the cost of generating and injecting steam or water for extended period of time. Another cost might be added, the expenses of employees and troubleshooting malfunctions in the process.

Equipment: The last criterion that must be evaluated is the use of equipment and machinery needed to implement the secondary recovery methods. Both solutions would require importing a large amount of machinery to the field.

DESCRIPTION OF THE FIRST OPTION

Water Flooding: The primary goal of a water flood is to increase overall production by injecting water into a reservoir through injection wells and producing offset wells (Fig. 2). The injection rates must be optimized to produce the highest production rates. Depending on the location water must be imported or piped to the well sites. The dominant mechanism of a water flood is immiscible displacement, according to (7). This refers to the displacement of the oil by the injected water. The water and oil can not mix. Therefore, the injected water pushed the remaining oil towards the production wells. Water flooding is the most widely used post-primary recovery method around the world because of the effectiveness at a relatively low cost.
Water floods are implemented in reservoirs with a wide range of screening criteria. They are generally used in lighter oil reservoirs because of the low resistance to flow. Water floods can implemented successfully at any reservoir depth.



(Courtesy: www.enhancedoilrecovery.com) (8)

Fig. 2. Water flooding Process

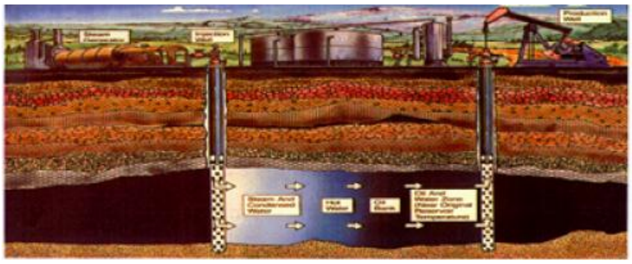
The cost of a water flood is relatively low compared to alternate secondary recovery methods. The cost of water flood would consist of expenses of surface equipment and imported water adding the maintenance of surface equipment. Table -2 lists favorable geological factors for successful water floods.

Table 2. Factors Favorable for Water flooding (Willhite, P. G., 1986) [7]

API Gravity	20˚ – 60˚ API
Viscosity	< 15.000 cp
Oil Saturation	>40%
Porosity	>20%
Permeability (average)	>10 md
Oil Zone Thickness	>15 ft
Reservoir Depth	>1000ft

DESCRIPTION OF THE SECOND OPTION

Steam flooding: The primary goal of a steam flood is to inject steam into a heavy oil reservoir to lower the viscosity and push the oil from the steam injected wellbore to the producing wellbore (Fig. 3). The injection rate must be optimized to produce the highest production rates. Limitations on injection rates may occur in case low availability of water from water wells and natural gas near the location.



(Courtesy: www.enhancedoilrecovery.com) (8)

Fig. 3. Steam flooding Process

The dominant mechanism in a steam flood is the reduction of oil viscosity allowing the fluid to flow easier (9). The heat of the steam causes oil to undergo physical and chemical changes within the reservoir. The physical changes from the heat include the decrease viscosity, specific gravity, and interfacial tension. The chemical change is referred to cracking, which is the destruction of carbon-carbon bonds to generate lower molecular weight compounds (10). Steam floods are generally implemented in shallow, heavy oil reservoirs. In deeper wells, steam loses heat energy to the pipe causing the flood to be less effective. Steam floods are implemented in heavy oil reservoirs because of the reduction of viscosity by the heat. According to (11). Steam floods, it may be used in light oil reservoirs when water injection does not work effectively. Table -3 lists favorable geological factors for successful Steam floods.

Table -3 Factors Favorable for Steam flooding (Matthews, C. S., 1983) [12]

API Gravity	10˚ – 34˚ API
Viscosity	< 15.000 cp
Oil Saturation	>40%
Porosity	>15%
Permeability (average)	>10 md
Oil Zone Thickness	>15 ft
Reservoir Depth	<5000ft

The cost of a steam flood depends on the amount of steam injected. Water and natural gas generate additional expenses and are required to produce the steam. Surface equipment and required service is also must be accounted into to the total cost of a steam flood. The total cost of a steam flood varies depending on the steam injection rates and duration of the project.

ASSESSMENT OF THE CRITERIA

Water flooding: The geological characteristic of the reservoir match perfectly. All of the factors favorable for a water flood are consistent with the characteristic displayed in the reservoir. Therefore, a water flood is predicted to be successful in the Messla oil field. The cost of a water flood in the Messla oil field would be dependent on injection equipment at the surface, transportation of the equipment and annual services. The field currently produces a sufficient amount of water to perform the water flood. So probably there will be no cost added with imported water. The cost of a water flood in the Messla field will be based on the expenses of $?/ unit and for how long?. Surface equipment for the water flood would need to manufactured and imported to the field. An additional cost for transportation would also be added to the final cost.

Steam flooding: The geological characteristics of the reservoir and the factors favorable for steam flooding are very similar. The only two characteristic that do not much are the reservoir depth and API gravity. The reservoir depth is 8550 ft and a steam flooding favor reservoir depth < 5.000ft also API gravity is 36.7º and a steam flooding favor API 10º – 34º API. However, Steam flooding can be used in light oil reservoirs when water injection does not work effectively. (11),(13)&(14). In the 1960s, one of the first light-oil steam flood field trials was injected at the Brea Field near Los Angeles, California (15). In 1970, Chevron Petroleum Technology Company applied steam to USA light oil reservoirs (16) (17). The use of steam drive as a primary recovery method showed a further 5% increase in cumulative oil production (18). The cost of the steam flooding would be dependent on the surface equipment, transportation of equipment, injection rats and annual services. The field currently produces a sufficient amount of water to perform the steam flood.

CONCLUSION

Based on the assessment of the geological criteria of both water flooding and steam flooding in the Messla oil field, water flooding is the best option. The factors favorable for water flooding are significantly displayed by the characteristic of the reservoir. The cost of a water flood in the Messla oil field would be dependent on injection equipment at the surface, transportation of the equipment and annual services. Although water flooding is the best option for the Messla oil field and is highly recommended, there might be need for applying steam flooding if water injection does not work effectively.

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NOMENCLATURE

AGOCO	Arabian Gulf Oil Company
ºAPI.	Oil gravity
bbl	barrel
BBL	Billion barrels of petroleum liquids
Cp	Centipoise (Unit of viscosity)
ºF	Fahrenheit
Ft	Foot
IOR	Improved Oil Recovery
mD	Millidarcies (Unit of permeability)
MMBBL	Million Barrels of Oil
NOC	National Oil Corporation
OOIP	Original Oil in Place
PVT	Pressure Volume Temperature
Stb	stock tank barrels
USA	United State of America
>	more than
<	less than
@	at
$	US Dollar
%	Percentage

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