المؤتمر العلمي الدولي الأول للهندسة و العلوم
The First Scientific International Conference in Engineering & Science

http://bwu.edu.ly/icse2022
Received 30/07/2022 Revised 30/12/2022 Published 05/01/2023
icse@bwu.edu.ly *ترسل الورقات كاملة علي

Applications of EOR Azzaytuna Analysis as a New Tool for Screening of Enhanced Oil Recovery Methods

Mohamed Baqar[a]*, Hamza Meelad[b], Hana Sheikh[c], Ayman Allsaed[d], Mohammed Mohammed[e], Bader Awedat[f]
[a,b,c,d,e]Department of Petrolum Engineering, College of Engineering/Azzaytuna University, Libya
[f]College of Information Technology/Azzaytuna University, Libya
*Corresponding author: msb134@case.edu

Abstract: The production of oil through reservoirs generally run through series of production stages. It can be classified as primary, secondary and tertiary (enhanced oil) recovery techniques. In the EOR stage, several processes and technologies are used to increase or uphold recovery from existing fields. These processes often involve the injection of fluid(s) and most recently microbes into a reservoir. Therefore, maintaining and increasing oil production from existing fields require proper selection, design, and implementation of EOR methods. One of the most used method for quick screening of the different EOR techniques is considering the successful previous experiences from the methods that have been applied in other fields. In this paper, an EOR screening tool has been designed using visual basic studio based on the recently reported EOR projects over the world. The developed tool, which is named " EOR Azzaytuna Analysis", is applied for one of the partially depleted reservoir that is located in Al-Zenad Farrud oil reservoir in Libya. The obtained results from "EOR Azzaytuna Analysis" have been compared to the obtained ones from the most common EOR screening tool known as EORgui. Both results were in-agreement and concluded that immiscible and CO_2 injection method, are the most viable options for the selected field understudy.

Keywords: (Enhanced Oil Recovery, Oil Reservoir, Screening Criteria, Screening Tool)

Introduction

The production of oil and gas from hydrocarbon fields are generally divided into three stages. In the initial stage, the production occurs naturally, whereas, the next stage when the reservoir pressure is not enough for supporting the production from the formations, other techniques such as water flooding and gas injection are applied. Generally, water flooding is the main driving mechanism for maintaining reservoir pressure because of availability and low cost of injection fluid. However, oil recovery using this flooding process is not high enough [1]. In the tertiary recovery stage, commonly known as enhanced oil recovery (EOR), it is possible to recover almost 30-60% of the field's original oil in place (OOIP) which is high compared to primary and secondary recovery methods where recovery factor is equal to 20-40% [2]. Despite that the main goal of EOR is to mobilize the remaining oil after primary recovery, no single process can be considered an optimal oil recovery from every reservoir. In addition, every well has to be treated differently according to the nature of that well. Therefore, screening must be carried on to determine which EOR method is the best and most efficient to be used on the selected well. Data of the well such as petro-physical, chemical, geological, environmental and fluid properties (density and viscosity which are dependent on temperature) must be taken into consideration and this will be the criteria of the screening process. Selecting the suitable EOR method by screening the reservoir and fluid properties can ultimately reduce the risk by eliminating inefficiencies.

Problem of Statement

Al-Zenad Farrud oil reservoir is located in the western Sirte Basin of Libya. Solution gas drive

was considered to be the predominant mechanism for the primary depletion. Recent data indicate the partially depletion of the reservoir which suggests the use of any suitable EOR methods.

Study objectives

In continuation of our study regarding the development of a new tool for screening criteria. The tool, which is known as "EOR Azzaytuna Analysis", was designed using visual basic studio and the database is based on the successful previously reported EOR projects. The tool will be used for Al-Zenad Farrud as a screening criteria of EOR techniques according to the data provided. The applicability of using this tool will be tested and the obtained results will be compared with the results obtained from the commercially well known tool named EORgui. The output data for both tools will be highlighted.

Methods

The methodology used in this paper include

1- The EOR Azzaytuna Analysis tool has been programmed according to the reported method in Azzaytuna University circles [3].

2- The data required for the Al-Zenad Farrud oil reservoir have been collected.

3- Input data has been proceeded as requested from the EOR Azzaytuna Analysis tool.

4- Screening criteria for Al-Zenad Farrud oil reservoir has been processed using the developed tool.

5- The same data of Al-Zenad Farrud oil reservoir have been acquired using the "EORgui" for comparison purposes.

6- The results of both tools have to carefully be further analyzed.

Data of Studied Reservoir

The data of Al-Zenad Farrud oil Reservoir is gathered and tabulated as shown in Table 1.

Table 1: Input data for the screening

Reservoir and fluid properties	Value
API gravity	38.57
Oil viscosity (cP)	0.61
Temperature	180 ˚F
Permeability (md)	72.93
Formation	Carbonate
Oil saturation (%)	0.724
Oil composition	C1-C7%
Reservoir thickness (ft)	>20
Reservoir depth (ft)	6170

Development of EOR Azzaytuna Analysis tool

Previously, the selection of the most applicable technique for EOR method was achieved manually using SPE format. This format is based on field experience and project execution worldwide. Therefore, this format was the beginning of all tools regarding the EOR screening. The format consists of five plots which are the viscosity plot, the permeability plot, the depth plot, the plot of reservoir pressure vs. oil viscosity and the plot of reservoir depth vs. viscosity, and the oil gravity range for EOR methods. Recently, several techniques have been designed for EOR screening [4,5]. In common of these tools, a user can screen oil fields directly and quantify incremental production for potentially applicable EOR techniques.

EOR Azzaytuna Analysis is a tool, which was developed using C++. The routine of the tool taking into consideration the already published screening criteria by Taber et al. in 1997 [6,7]. It is based on the EOR screening criteria, which were updated by A. Aladasani and B. Bai [8]. In this tool, the user can quickly screen an oil field in order to determine which EOR method(s) is/are more suitable to be applied. Eight methods of EOR are available using nine reservoir and oil properties, such as API

gravity, viscosity, hydrocarbon composition, thickness, permeability, and oil saturation, type of the reservoir formation, thickness, depth and temperature, resulting in the most suitable EOR method for each oil field [9]. EOR Azzaytuna Analysis is designed and developed in order to make the selection of EOR methods easier and faster. A simple flow chart of the tool is described in Fig 1.

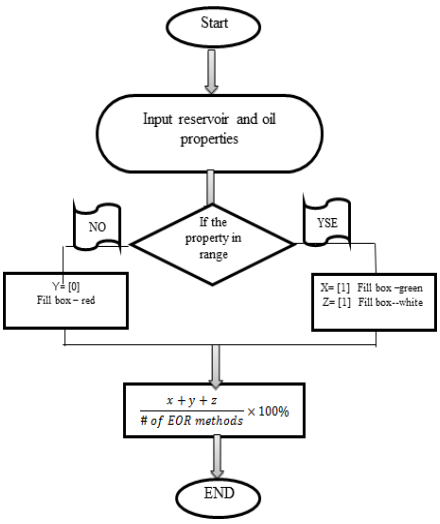

Fig. 1: Flow chart of EOR Azzaytuna Analysis

The database has been designed according to the successful previous experiences from the methods that have been applied in other fields. Gravity, as an example of the entry code for the eight EOR methods are shown in Fig. 2. The overall matching percentage for the selected EOR method is then calculated according to the following equation :-

$$P(x) = \frac{x+y+z}{\#\ of\ EOR\ methods} * 100\%$$

Where P(x) = overall matching percentage for the selected EOR method

x = the amount of matching properties

y = the amount of mismatching properties

z = the amount of neglected properties (not critical entry)

```
End Sub
0 references
Private Sub Button1_Click(sender As Object, e As EventArgs) Handles Button1.Click
    Try
    clear_All()
    DGV1.Rows(1).Cells(0).Style.BackColor = Color.Green
    If Val(txt_Gravity.Text) >= 35 And Val(txt_Gravity.Text) <= 54 Then
        DGV1.Rows(0).Cells(2).Style.BackColor = Color.Green
        A_Netrogen += 1
    Else
        DGV1.Rows(0).Cells(2).Style.BackColor = Color.Red
    End If
    If Val(txt_Gravity.Text) >= 23 And Val(txt_Gravity.Text) <= 57 Then
        DGV1.Rows(0).Cells(3).Style.BackColor = Color.Green
        A_HadroCarbon += 1
    Else
        DGV1.Rows(0).Cells(3).Style.BackColor = Color.Red
    End If
    If Val(txt_Gravity.Text) >= 22 And Val(txt_Gravity.Text) <= 45 Then
            DGV1.Rows(0).Cells(4).Style.BackColor = Color.Green
            A_Carbon_Dioxide += 1
    Else
        DGV1.Rows(0).Cells(4).Style.BackColor = Color.Red
        End If
        If Val(txt_Gravity.Text) >= 12 Then
            DGV1.Rows(0).Cells(5).Style.BackColor = Color.Green
            A_Immiscibie_Gases += 1
        Else
            DGV1.Rows(0).Cells(5).Style.BackColor = Color.Red
        End If
        If Val(txt_Gravity.Text) >= 20 And Val(txt_Gravity.Text) <= 44 Then
            DGV1.Rows(0).Cells(6).Style.BackColor = Color.Green
```

Fig. 2: Coding of the Gravity

The database entry into the tool are shown in Fig. 3.

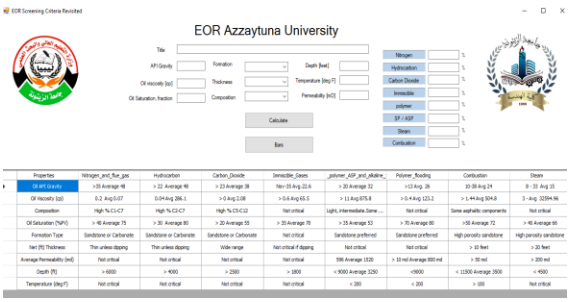

Fig. 3: Database of EOR Azzaytuuna Analysis

Application of EOR Azzaytuna Analysis

It should be noticed that the database in the EOR Azzaytuna Analysis contains input as screening criteria by (Al-adasani and Bai, 2010). After entering the acquired information data, the tool was performed and the results were extracted as shown in Fig. 4.

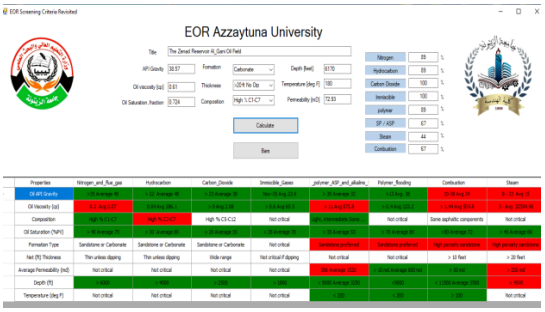

Fig. 4: Quick and database screening using EOR Azzaytuna Analysis

It can be seen that the ratio of matching each EOR methods were represented as a

percentage of entered data of Al-Zenad Farrud oil Reservoir to the database of the reported ones. It is clear that the highest percentage was for Immiscible and Carbon Dioxide methods with (100%). The Nitrogen and Hydrocarbon and Polymer methods are (89%). The Combustion and Polymer-ASP methods with (67%), whereas the Steam method shows the least ratio percentage of (44%).

For clarity purposes, the tool is performed in a color coded mode. A dark green color in the codes represents the match conditions. However, the white color, means value is neglected (not critical). The red color means it does not meet the conditions of the table. The results for the two methods (Immiscible and Carbon Dioxide) show four codes in dark green. Since there are no red codes for the two methods, they considered the best applicable EOR methods. The second choice is the methods Polymer and Hydrocarbon, Nitrogen where each method has one red code. In methods of Combustion and Polymer-ASP, the software shows three red codes. Lastly, a Steam method is not recommended due to more codes in red.

EORgui screening Tool:

EORgui tool [10] has been used to select the optimum EOR method for Al-Zenad Farrud oil reservoir. Fig. 5 graphically represents the recommended methods. The screening shows immiscible gas to be the most suitable EOR method for " Al-Zenad Farrud oil reservoir" with a high percentage matching of 83%. The ability to applying Carbon dioxide Miscibility flooding for this field is about 78%. The SP/ASP and Combustion methods are ranked next with a matching of 73% and 67%, respectively. Nitrogen and hydrocarbon flooding are not strongly recommended for this case as they are ranked last.

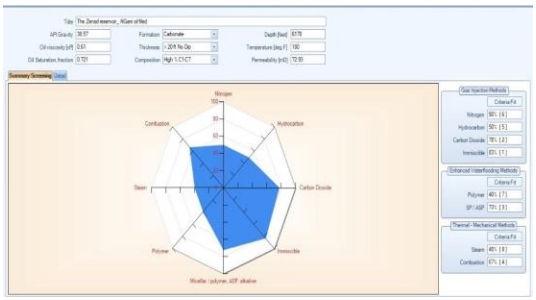

Fig. 5: Quick screening using EORgui

Fig. 6 shows the database and the obtained screening results of Al-Zenad Farrud oil reservoir using EORgui.

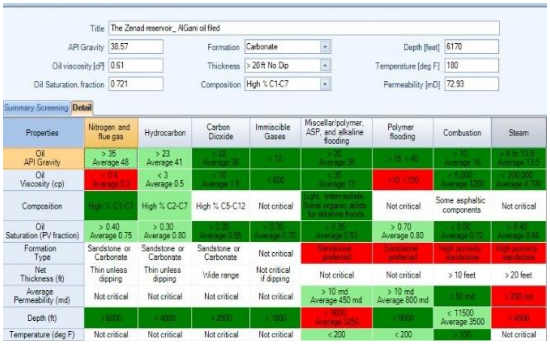

Fig. 6: Database screening using EORgui

Comparative analysis for the case study

-The obtained results, as the best applicable EOR methods, from both tools (EORgui and EOR Azzaytuna analysis) are shown in Table 2.

Table 2: The best applicable EOR methods

Screening tool	Suitable EOR methods
EORgui	-Immiscible method (83%).
	-Carbon dioxide_CO_2 Miscibility flooding (78%).
EOR Azzaytuna Analysis	-Immiscible method (100%).
	-Carbon dioxide_CO_2 Miscibility flooding (100%).

It is clear that the suitable EOR methods based on the screening results for Al-Zenad Farrud oil reservoirs are: the immiscible and the CO_2 injection. However, the use of enhanced oil recovery techniques will not be initiated unless they have an economic return. This result considering the application of CO_2 in enhanced

oil recovery and because it is a preferred technology for reducing carbon dioxide emissions into the atmosphere.

Conclusions

The use of EOR Azzaytuna Analysis as a newly developed tool for EOR screening makes it faster than just using a time consuming manual screening method. The results through "Al-Zenad Farrud oil reservoir" showed that the developed tool has the capability to do selection of suitable EOR based on the data provided. The recommended EOR methods are both immiscible and carbon dioxide flooding. The obtained results was in agreement with the results obtained using EORgui as a screening tool.

Recommendations

The following recommendations could be taken into account

1. The results of applying any EOR methods do not start to appear quickly, as years may pass before judging the success or failure of the technology used. Therefore, the risk factor is high, whether technically, environmentally or economically. This means that frequent update of these developments is an important step of this tool.

2. Another analysis methods, such as the calculation of recovery factor, economical analysis calculations, the most cost effective method, cost of facilities and equipment and the availability of the injected fluid have to be implemented as a package in this tool.

References

1- Pwaga, S., "Comparative Study of Different EOR Methods". Trondheim: Norwegian University of Science and Technology, 2010.

2- Hama, M. Q. "Updated screening criteria for steam flooding based on oil field Updated screening criteria for steam flooding based on oil field projects data", Masters theses, Faculty of the Graduate School of the Missouri University of Science & Technology, Spring (2014).

3- A. Alhadi, H. Mohamed, H. Saleh, M. Mohamed, "Development of a new software for screening of enhanced oil recovery methods", BSc thesis (2022)

4- Urayet ; A.A. "Advanced Topics in Petroleum Engineering". University of Tripoli. Tripoli, Libya (2004).

5- Mohamad Faizzudin B Mat Piah, "*Enhanced Oil Recovery Field Development: Process Flow of EOR Selection for Sandstone Formation*". B.Sc. Project, Dept. Pet. Eng., University Technology. PETRONAS. SEPTEMBER 2012.

6- Taber, J.J., Martin, F.D., Seright, R.S. (1997), EOR Screening Criteria Revisited – Part 1: Introduction to Screening Criteria and Enhanced Oil Recovery Field Projects., Society of Petroleum Engineers Reservoir Evaluation & Engineering SPERE, doi:10.2118/35385-PA, pp. 189-198.

7- Taber, J.J., Martin, F.D. Seright, R.S., (1997), EOR Screening Criteria Revisited – Part 2: Applications and Impact of Oil Prices", Society of Petroleum Engineers Reservoir Evaluation & Engineering SPERE, doi:10.2118/39234-PA, pp. 199-206.

8- Al-Adasani, A., Bai, B. (2010), Recent Developments and Updated Screening Criteria of Enhanced Oil Recovery Techniques., SPE-130726-MS. Presented at the International Oil and Gas Conference and Exhibition, Beijing, China, 8 – 10 June 2010.

9- T. Ahmed, Reservoir Engineering Handbook. (4th ed.) Houston: Gulf Professional Publishing, 2010.

10- EORgui 1.1 Software, Technical Manual, [online] available at: www.Petroleumsolutions, Co. UK, Petroleum Solutions Ltd, 2005–2010.