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Analysis of the Producer Wells Position Relative to Anode and Cathode Well on ESOR (Electric Stimulation Oil Recovery) Implementation at EIO Field.

Eka Istianti Octavia[1,a)], Dyah Rini Ratnaningsih[2,b)], Dedy Kristanto[2,c)]

[1]*PT Pertamina Hulu Energi , Jl TB Simatupang Jakarta, Indonesia.*
[2]*Lecturer, UPN Veteran Yogyakarta , Jl Padjajaran Sleman Yogyakarta, Indonesia*

Corresponding author: [a)] eka.octavia13@gmail.com
[b)] rini_diah@yahoo.com
[c)] dedykris.upn@gmail.com

Abstract. The EIO field is an oil field where is categorized as low priority and mature. Based on 2018 reserve report, EIO field has produced 48% of its original oil in place, with a remaining reserve of 2.074 MSTB. Based on remaining reserve, there is still potency to optimize the ultimate recovery of this field. ESOR is a new kind of enhanced oil recovery method which uses electricity directed to reservoir using existing two wells each as an anode and a cathode. The implementations of ESOR, there are three ways of how this method can improve oil recovery from reservoir, they are electrokinesis effect, Joule heating, and cold cracking. Based on production decline curve analysis on observation well after ESOR implementation, it is known that all observation well experience decrease on monthly decline rate (*De*). Monthly *De* of E-20 well decreases from 14% to 7.73% which results on additional recovery of 7.1 Mbbl. E-21 well from 39.82 % to 6.47% with additional recovery of 2.22 Mbbl. E-22 from 3.36% to 1.80% with additional recovery of 32 Mbbl. The analysis of the proximity of wells to changes in the decline rate and changes in API found that the farther the observation wells are from electrically charged wells, the smaller the changes in the decline rate of wells that occur. Likewise with changes in API gravity which is directly proportional to the ability of the electric field charge formed of the electric current from the anode well to the cathode well, the farther the location of the well from the electric field, the smaller the change in API gravity that occurs.

Keywords: *Electric stimulation, enhance oil recovery, production optimization.*

INTRODUCTION

EIO Field is an oil and gas which is categorized as low priority and mature field. Based on 2018 reserve report, EIO field has produced 48% of its original oil in place, with a remaining reserve of 2.074 MSTB. Based on its remaining reserve, there is still potency to optimize the ultimate recovery of this field. EIO Field was initially founded by a Dutch oil company (NKPM) in 1938 with total of 21 wells drilled and 4 wells still on production. Reservoir in this field consists of sandstone from Lemat Formation. Driving mechanism of the production reservoir is consist of water and gas solution drive. The current condition of the reservoir is in depletion stage so it is required "out of the box" solution to recover the remaining oil and contribute to national oil and gas production.

Conventional EOR implementation in EIO Field is difficult to study because of insufficient data such as SCAL and PVT analysis since it was initially developed in early 1900s. However, with the advance in science, research, and technology, there is an alternative enhance oil recovery method that required less data and easy to be implemented in such a field that called Electrical Stimulation Oil Recovery or ESOR. This paper will discuss whether this method is suitable in EIO field and parameters improvement related to ESOR implementation.

ESOR Concept

The technological concept of ESOR is by creating electrical flow of DC current through the well casing and the reservoir by installing electrical conductor on the surface of certain well as anode and another well as cathode. Figure 1 shows the illustration of this concept. Dr. G.V Chilingar of University of Southern California [1],

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conducted study related to electrical based enhanced oil recovery on an oil field in California which concluded that the implementation of such technology on the field producing 8 degAPI oil has successfully increased the oil production by the degree of tenfold of its original production.

DC current is transmitted through cable to surface transmission equipment into the reservoir from anode well to cathode well. This transmitted current will result in electrokinetic phenomenon in the reservoir which will result in the improvement of oil API gravity thus improvement in oil production. On the other hand there will also be Joule heating effect and cold cracking effect which will also occur and contribute to oil production improvement.

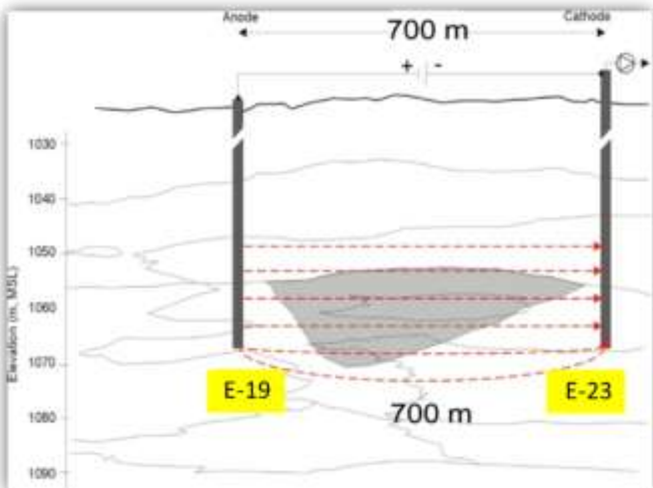

FIGURE 1. Schematic of ESOR

Selecting Anode and Cathode Well

In terms of ESOR implementation on EIO Field, two wells will be selected as anode and cathode well. The selection of anode and cathode well is based on the subsurface location of wells in the area and considering the pattern of electrical movement in the reservoir. Producing wells between the anode and cathode well. will be considered as monitoring wells that will be affected by electrical field created from DC current flow in the reservoir. Figure 2 shows the subsurface map of EIO Field. The data of distance well shows in Table 1.

TABLE 1. Distance observation well to anode-chatode well

Well	Distance from Anode Well (E-19), m.	Distance from Anode Well (E-19), m.	Average Distance from Anode & Cathode well, m.
E-20	247.7	341.3	294.5
E-21	379.1	376.3	377.7
E-22	457.9	157.2	307.5

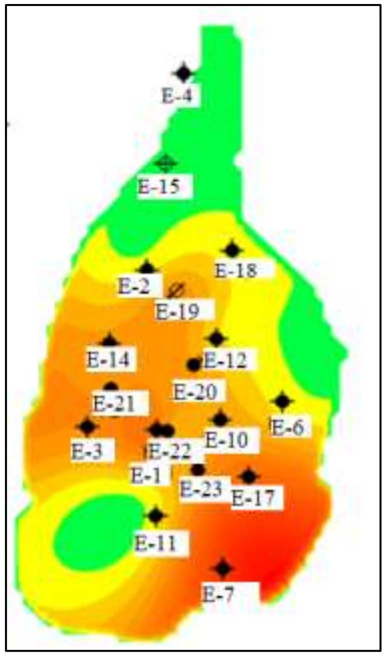

FIGURE 2. Well Location of EIO Field

There are only 4 active producers currently producing in EIO Field, they are E-20, E-21, E-22, and E-23. By considering well location relative to each other, E-19 (suspended) was chosen as anode well. In the other hand, E-23 (active producer) was selected as cathode well. Figure 3 shows the estimated area affected by ESOR implementation using E-19 as anode and E-23 as cathode.

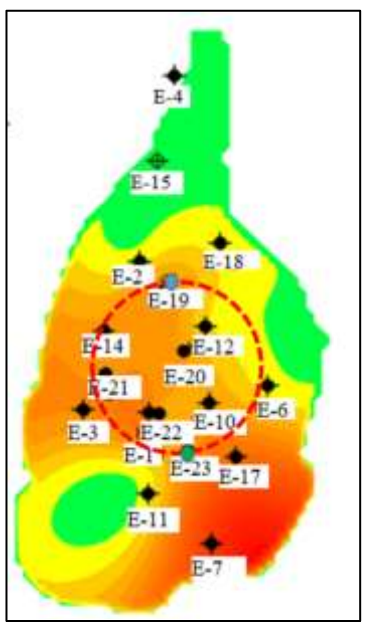

FIGURE 3. Estimated Area Affected by ESOR

RESULT AND DISCUSSION

Evaluation of ESOR Implementation

The evaluation implementation of ESOR was done by observing production and well parameters located between E-19 and E-23 which are E-20, E-21, and E-22 by comparing API gravity, production performance before and after well implementation.

ESOR Effect on Oil API Gravity

Three mechanisms affect API oil gravity from implementing EEOP, they are hydrocarbon cold cracking and Joule heating effect. The cold cracking effect reduces oil API gravity by breaking long chain hydrocarbon into smaller ones thus reducing oil API gravity and its viscosity. In other hand, Joule heating effect occurs due to resistance on current flow media in reservoir which are result from oil heating in the reservoir. These effects can be observed on all monitoring well which showed in Figure. 4.

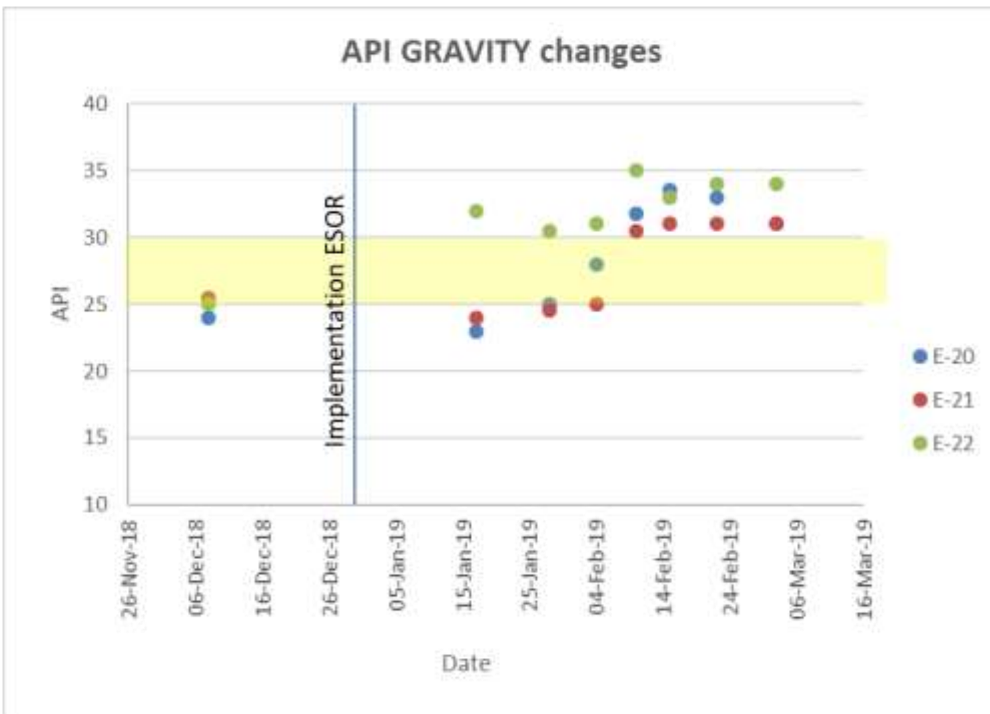

FIGURE 4. Oil API Gravity Improvement of E-20, E-21 and E-22 before and after implementation ESOR

Decline Curve Analysis

Decline curve analysis is done to evaluate the effect of ESOR implementation on decline rate and recoverable reserve of monitoring wells. The analysis indeed shows dome degree of decline rate decrement. Monthly decline rate of E-20 decrease from 14 % to 7.73%, E-21 from 39.32% to 6.47%, E-22 from 3.36% to 1.8%. The decrease of decline rate will increase remaining reserve.

Effect of Anode and Cathode Well Position Relative to Observation Well on Change in the Decline rate (De) and API Gravity

The evaluation was also carried out by observing the position of the observation wells with anode/cathode wells on Decline rate (De) changes and increase in API gravity. The effect of distance of observation well and the anode/cathode well to the delta changes in De shown in Fig. 5. It can be seen that the closer average spacing of the observation well to the anode/cathode well, the greater the change of De.

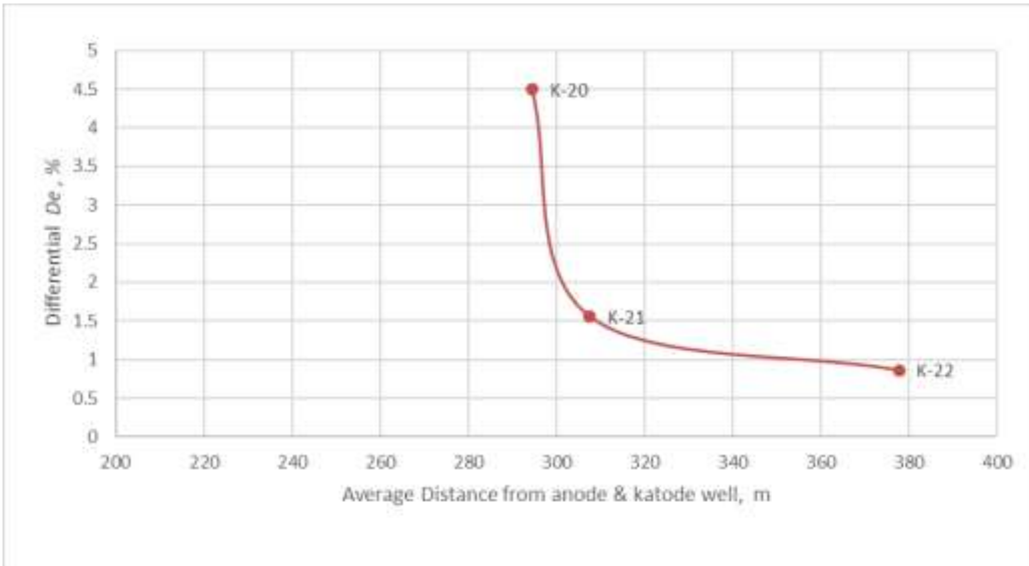

FIGURE 5. Differential De vs Average Distance from Anode & Chatode Well to Monitoring Wells

The Connect distance of the observation well and the anode/cathode well to the API changes is done by calculating the magnitude of the electric field strength with formula (1). Furthermore, to prove the change in the API, a graph of the relationship between changes in the differential API gravity and the electric field strength was made as shown in Fig. 6. It can be seen that the greater the electric field that occurs in the observation, the greater the change in API that occurred.

$$E = \frac{F}{q} \ \ or\ E = k\frac{q}{r^2} \tag{1}$$

Notes:
E = Magnitude of the electric field (N/C)
F = Coulomb or electrostatic (N)
q = Electrical charge (C)
K = 9×10^9 Nm^2/C^2 (Constant)

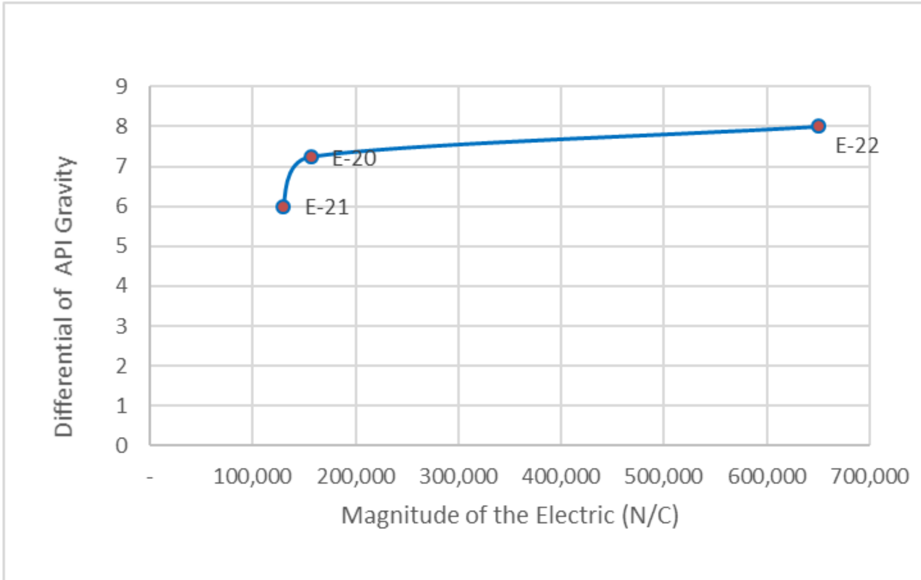

FIGURE 6. Magnitude of the electric field with API Gravity

CONCLUSIONS

From this research, there are several conclusions regarding ESOR implementation in EIO Field:

1. The Implementation of ESOR changes the Decline rate (De) of the oilwell, where the closer average distance of the observation well to the anode/cathode well, the greater the De change that occurs.
2. The Implementation of ESOR changes the API gravity in monitoring wells produced oil, which between 6-8 ^{0}API.
3. The position of the observation well related to the implementation ESOR determines the strength of the magnetic field that affects in degree of changes of the oil API Gravity.

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