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Immiscible CO2 EOR Injection Coreflooding Optimization using Compositional Simulation Model for Sumatera Light Oil Field

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Abstract

Many wells in Sumatra Field have already a decline in production after being produced naturally, but still have oil left in the reservoir. Therefore, there is a technique to produce the remaining oil reserves in the reservoir, it is called EOR (Enhanced Oil Recovery). EOR (Enhanced Oil Recovery) is basically defined as lifting oil with various methods such as Chemical flooding, Thermal Recovery and CO_2 injection.

This paper describes Matching EOS model and Current Pressure CO_2 injection Continous scenario of Coreflooding Simulation based on laboratorium experiment. PVT data of EOS modelling are Differential liberation, Constant Composition Expansion, Separator, Swelling test and MMP using CMG Simulator (Winprop). The PVT data sample used combination from the PVT data initial and PVT data current data property, therefore the fluid model resprents proper current reservoir property to be used in coreflooding simulation scenario.

Matching the scenario experiment data of coreflooding process simulation to get some parameter like injection rate, The value of SORW, Oil Viscosity..Therefore, the simulation model were valid to run sensitivity study over different scenario of injection such as continous CO_2, various slug size, WAG and WAG ratio. Based on the purpose of this paper, this paper can be used for many various sensitivity of coreflooding simulation with one PVT data of laboratorium experiment and one scenario data coreflooding simulation to find the best scenario for the optimum of recovery factor.

From the results of this study, it can be used for field development by upgrading the coreflooding model into a field model and also which scenario is the best for implementing.

Keywords: Enhanced Oil Recovery, Immiscible CO2 Injection, Coreflooding Simulation

Introduction

For further field developments where natural production has been carried out, usually tertiary production will be to do for the next production step. There are several types of tertiary production, there are Chemical Injection, Gas Injection, and Steam Injection.

The tertiary production in this paper is by using CO2 Gas Injection. There are 2 methods for CO2 injection, Miscible CO2 Injection and Immiscible CO2 Injection. To determine whether the injection is Miscbile or Immiscible, it is necessary to know the value of the Minimum Miscibility Pressure (MMP). MMP values can be obtained by slimtube laboratory, and correlation. In this paper, an immiscible CO2 injection will be used because the MMP value is higher than the fracture pressure.

To support tertiary production, a Fullfield simulation model should be done. One of the steps to do a Fullfield simulation model is coreflooding simulation. In this coreflooding simulation, there are several scenarios, there are Continuous CO2 Current Pressure, Continuous CO2 Initial Pressure and WAG Initial Pressure. In this paper,CO2 Coreflooding Simulation uses CMG GEM Simulation

Data and Method

EOS Modelling

To perform a full-field model Simulation CO2 injection simulation, several steps are required, including the following:

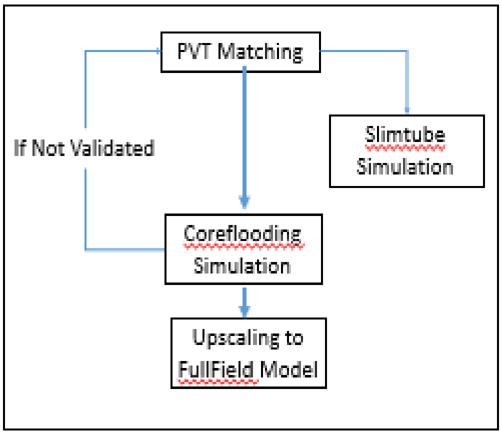

Figure 1: Workflow

Component	Initial Condition		Current Condition	
	Mol %	Weight %	Mol %	Weight %
CO2	2.38	0.66	1.97	0.43
N2	0.22	0.04	0.24	0.03
C1	23.86	2.43	7.94	0.63
C2	3.32	0.63	1.15	0.17
C3	3.88	1.09	1.98	0.43
i-C4	0.77	0.28	0.72	0.21
n-C4	1.08	0.40	1.38	0.40
i-C5	3.57	1.63	1.13	0.40
n-C5	2.38	1.09	1.22	0.43
C6	4.06	2.21	3.72	1.58
C7+	54.58	89.24	78.55	95.30

Tabel 1 : Initial Composition and Current Condition Composition

The Equation of states Peng Robinson (1978) was used in this paper. By combining PVT data on initial conditions and PVT data on current conditions. PVT matching was performed based of result laboratory data such as Saturation Pressure, Constant Composition Expansion, Differential Liberation, Viscosity, Etc.

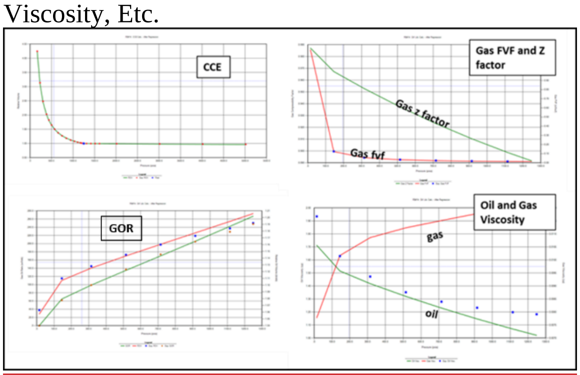

Figure-2 : PVT Matching Initial Composition Data

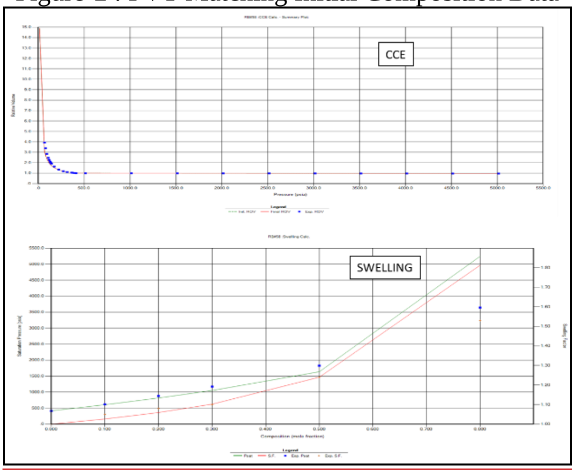

Figure-3 : PVT Matching Current Composition Data

Minimum Miscibility Pressure

Determining the minimum miscibility pressure can be done in two ways, namely the slimtube laboratory experiment and its correlation. The most commonly used method is to graph the oil recovery after 1.2 PV of gas injected at each injection pressure. The three MMP Criteria using the graph are;

1. MMP when the curve starts to bend.
2. MMP at the inflection point with oil recovery greater than 95%.
3. MMP where the oil recovery is greater than 95%.

To determine the MMP by correlation, the correlation used is the correlation of Cronqruist, Yellig and Metcalfe, Holm Jossendal. The MMP for those correlation are 2525 psia, 2300 psia and 2700 psia

In this paper, the MMP value in the laboratory results is 2700 Psia which will then be validated by the results of slimtube simulation

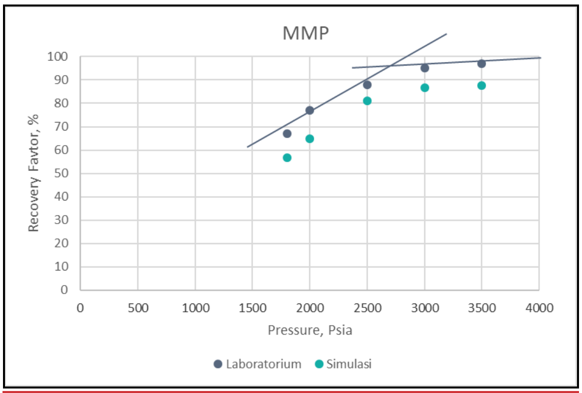

Figure-4: Results of MMP

Coreflooding Simulation Model

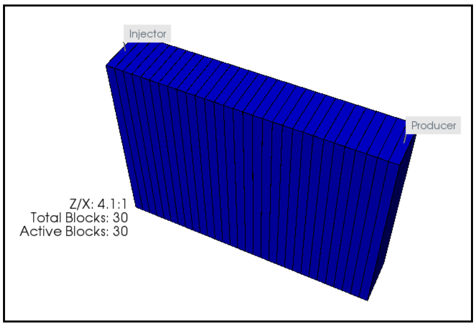

Figure-5: Coreflood Simulation Model with 1 Injector and 1 Producer

Sample Code	Depth	L	K_{He}	Stack Length	Diameter Avg	k avg	ϕ avg
	meter	mm	mD	mm	mm	mD	%
Core 1	811.36	26.86	67.31	195.80	37.7	58.25895	27.8
Core 2	811.65	31.12	68.98				
Core 3	811.70	31.14	64.76				
Core 4	811.86	35.13	52.75				
Core 5	811.94	36.87	52.84				
Core 6	823.55	34.68	52.07				

Tabel-2: Coreflooding Rock Properties

Based on Coreflooding Rock Properties, The model have 68.6 cc with oil saturation 30.1 cc (43.9 %) and water saturation 38.5 cc (56.1 %).

Result and Discussion

In this paper, a WAG scenario will be carried out with an initial pressure of 1250 psia. The steps in this WAG simulation are water injection first until Saturation Oil Residual (SOR) conditions which will then be followed by water injection up to 0.2 PV and gas up to 0.2 PV alternately. And finally flush injection with water until no oil is produced.

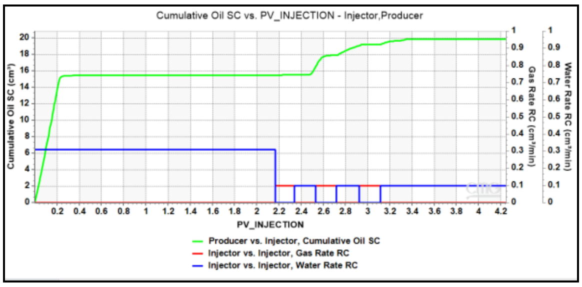

Figure-6: PoreVolume Injection vs Cumulative Oil WAG Scenario Coreflooding

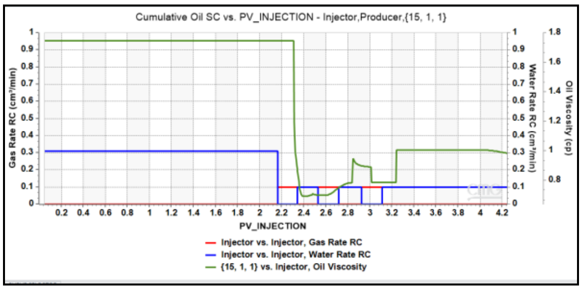

Figure-7 : Oil Viscosity at 15,1,1 Block

From the results of the WAG coreflooding simulation, it is found that the viscosity of the oil is reduced when the gas is injected and the results of the recovery factor are good based on the comparison of the results from the laboratory as follows:

Simulation		Laboratorium	
Recovery Factor Waterflood, %	51.3	Recovery Factor Waterflood, %	51.5
Recovery Factor WAG, %	63.7	Recovery Factor WAG, %	64.4
Incremental, %	12.4	Incremental, %	12.9

Tabel-3: Comparison Matching Between Simulation and Laboratorium

From the results of the WAG simulation which are in accordance with laboratory data, the PVT which used for this model can be used for other scenarios such as WAG injection at current pressure, continous CO_2, various slug size, WAG and WAG ratio to find the optimum scenario

Conclusions

From the results of this paper, this coreflooding simulation can provide output as input for the full-field model such as the PVT , the injection rate that needs to be upscaled, the value of SORW.

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