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Miscible CO_2 Injection: Sensitivity to Fluid Properties

F.M. Nasir, N.A. Amiruddin, Universiti Teknologi PETRONAS

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Abstract

Miscible gas injection has been identified to be the most amenable enhanced oil recovery (EOR) process for Malaysian oil fields. Due to economic and availability reason, carbon dioxide (CO_2) is the most potential source of gas for this process. In order to predict the performance of these fields undergoing miscible flooding using a reservoir simulation, there is a need to identify parameters that have significant effect on the results. Sensitivity study is usually conducted to evaluate the effect of varying parameters on the reservoir performance. This paper presents the results of the study using numerical simulation, with the emphasis on fluid properties since these data are usually obtained from laboratory measurements or correlations, which generally subjected to great uncertainties. Therefore, it is the main objective of this work to determine the fluid properties that have major impact on the oil recovery from miscible CO_2 injection. Using an extended black oil simulator, the effect of varying oil and injected gas density, viscosity and formation volume factor, on the flood performance is assessed. The effect is quantified using an index called normalized root-mean-square deviation and a fractional change index. From the results of the simulation, the model is found to be most sensitive to fluid formation volume factors, followed by their densities and least sensitive to the fluid's viscosities. Thus, it is recommended that these data must be properly selected and analyzed beforehand in order to minimize their uncertainty prior to any simulation works.

Introduction

The highly favorable oil price and the burgeoning demand for petroleum products as a source of energy as well as the limited oil reserves has accelerated the effort to further extend the life of hydrocarbon reservoirs. Majority of the effort is concentrated in pursuing development and implementation of tertiary recovery or Enhanced Oil Recovery (EOR). EOR is vastly applied by many oil producing nations especially nations where their reserves are in aging oil fields which are declining faster than the discovery of new oil reserves. A screening study performed by PETRONAS denotes that 52 out of 72 Malaysian reservoirs are technically feasible for the application of new EOR processes which estimates additional potential recovery of 1 billion barrels of crude oil [1]. Miscible gas injection has been identified to be one of the most amenable EOR process for Malaysian oil fields [1]. Due to economic and availability reasons, carbon dioxide (CO_2) is the potential source of gas for this process.

Prediction of field's performance undergoing miscible displacement is generally conducted by laboratory core flood experiments or reservoir simulation (either by black oil or compositional simulator). This work is focused on the latter. A reservoir simulation model is developed based on geologist's and engineer's best estimate of parameters describing the reservoir [2]. For a reservoir that has been producing for sometime, its model will be history-matched between actual production data to the predicted/simulated performance. The history-matching process is generally proceeds by modifying various parameters to minimize their differences. One of the parameter being modified is the PVT data. During this process, the engineer either assumes that these data are well known or is unaware of changes in simulation results to those data [2].

PVT or fluid properties data are generally obtained from laboratory measurements or calculated from published correlations, which may be subjected to uncertainties. The uncertainties in the description of reservoir fluid properties contribute to the total uncertainty in the reservoir description, which in turns affect the estimation of the in-place volumes and production profiles, and consequently the economical decisions [3].

Due to these facts, there is an important need to identify the properties that have significant effect on the performance prediction of miscible displacement. Therefore, the objective of this work is to determine the fluid properties that have major