Journal of Chemical Engineering & Process Technology

Experimental Validation of the Well Density Profile in Immiscible Gas Enhanced Oil Recovery Projects

Edward Gobina[*], Priscilla Ogunlude, Ofasa Abunumah

Department of Engineering, Robert Gordon University, uk

ABSTRACT

The well-density profile of Immiscible Gas Enhanced Oil Recovery (IGEOR) processes for CH_4, N_2, Air, and CO_2 has been rigorously investigated through data mining and experimental methods. Well-density has significant engineering and economic implications for EOR project evaluation because wells determine the amount of oil produced from reservoirs, and they are the most expensive subsurface infrastructure of an oilfield. Some authors have investigated EOR technology characterisation in the literature, nevertheless, these are few and currently no resources exist that have simultaneously evaluated the well-density competitiveness of the four gases commonly used in IGEOR. The outcome of this study has objectively contributed to reservoir knowledge and practice by indicating that Gas EOR processes can be characterised by well-density. It has been demonstrated that the CH_4 EOR process offers the lowest well-density (0.96 wells.cm^{-2}), while the CO_2 offers the highest well density (1.5 wells. cm^{-2}). This implies that selecting to inject CH_4 in reservoirs rather than CO_2 can reduce well cost and engineering complexity by nearly half. The structural rhythm that optimises well density in a heterogeneous and layered reservoir was found to be akin to a positive porosity gradient, that is, injection direction is from lower porosity region to higher porosity region. The low coefficient of variation of CO_2 in the data mining and experiments suggest that the recovery performance of the gas would be most sensitive to well density deviations. The quality of the coupled analyses indicates that the experimental results sufficiently validate the data mining results. Consequently, based on the order of competitiveness, the EOR gases rank as $CH_4 > Air > N_2 > CO_2$. This research finds direct utility in EOR screening of reservoirs and the selection of gases appropriate for the effective displacement of trapped oil.

Keywords: EOR cost; Reservoir characterisation; Injectants; Gas EOR; Well-density; Well cost.

INTRODUCTION

The well-density (W_{Den}) as shown in Eq. 1, is used to estimate the sum of injection (W_I) and production (W_P) wells required to optimally drain a unit area (W_P) of a reservoir undergoing a particular EOR technology [1,2].

$$W_{Den} = \frac{W_P + W_I}{A} \qquad 1$$

Shepherd stated that the optimal achievable drainage for a reservoir depends on the number of production and injection wells [2,3]. Therefore, suggesting that the coupling of EOR processes and Well-density to recover trapped oil in reservoirs has economic and engineering implications. The theoretical expectation is that some EOR processes and reservoirs may show a profile consistent with high well-density than others. This leads to the following questions:

How important is such knowledge to reservoir engineering? First, it is only a properly planned and executed well-density model that can effectively drain trapped oil, produce the maximum recovery efficiency, and minimise project complexity, such as well conversion, infill well drilling, maintenance, and shutdown.

How important is this knowledge to reservoir economics? Wells are the single most expensive subsurface activity in an oil field [2]. It takes between 15 to 27 million dollars and 10 to 40 days to drill a well [4-8]. Consequently, the ultimate economic aim is to minimise cost and maximise revenue. To an economist, therefore, the need to guarantee top management that these costs can be recovered from the incremental oil resulting from the drilled wells is paramount. However, where the correct connecting information such as cost and recovery performance is not available or applied in decision making, this could result in a catastrophic loss of revenue.

IGEOR is a subset of EOR technologies. It involves injecting gases