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A comparative economic study of cyclic CO_2 injection in unconventional oil reservoirs: effects of gas type and fracture spacing

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Production from ultra-low permeability Shale plays requires advanced technologies such as horizontal well with multistage hydraulic fracturing treatment. Due to highly conductive induced fractures, the stimulated well undergoes a sharp decline rate. In this study, a cyclic gas injection with two pumping schedules is introduced to increase oil recovery. Fracture spacing and type of injection gas in a horizontal well from Bakken are analysed through numerical simulations. The economic profitability and reservoir performance are also investigated. Rate transient analysis is used to anticipate hydraulic fracture and effective fracture permeability. Different fractures spacing are selected as major determinant in effective reservoir contact area. Compositional simulations are conducted to model incremental oil recovery after cyclic injection of three gases: natural gas, C_2, and CO_2. Fracking cost, gas and oil prices are used to evaluate overall profitability. Economic indicators of net present value (NPV), rate of return (ROR) and oil recovery factor are compared to determine the best alternative among the proposed investment scenarios. Current market and a certain time-frame (2015-2035) are used to assess viability of investment in unconventional oil plays.

For a 38° API oil, all the proposed scenarios showed positive NPVs ranging from $4.8M to $12.9M corresponding to widest and narrowest fracture spacing, respectively. Based on the assumption of current market, with 30% increment in oil price, maximum NPV growth reaches to 48%, while 30% decrease in oil price leads to -108% NPV decline. Fracturing cost is identified as second detrimental factor in profitability of the project with NPV variation between 9.13% and -11.23%. Least impactful parameter is the injection gas price with NPV changes less than ±5%. Cyclically injection of C_2 and CO_2, remarkably improved oil recovery from the Bakken. Natural gas injection however, led to inferior results and in terms of investment, may not guarantee the long-term success. The proposed injection schedules with cycle sizes designed in accordance with fracture spacings, effectively boost the recovery in widest spacings from $3.7M to $4.8M. Production of majority of cumulative oil during the first years, make most of the scenarios viable only for short terms. To maintain the long-term cost-effectiveness, performing cyclic gas injection through hydraulic fractures is recommended. Cycle sizes directly impacts on propagation of injectant and drainage volume. Increasing number of fracking stages can be an alternative strategy to the gas injection in reservoirs with lower oil-APIs.

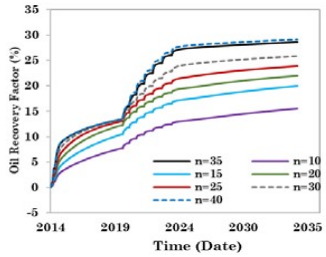

Figure 1. Recovery factor from CO_2 injection at different fracture stages

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