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Time-Dependent Performance Evaluation of Cyclic Injection of Gas Mixtures into Hydraulically-Fractured Wells in Appalachian Sandstones

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ABSTRACT

Single-well cyclic gas injection is a promising method to increase recovery from depleted and fractured reservoirs. The process is primarily driven by a diffusion process through the fracture surface, allowing the oil in the matrix to be displaced towards fractures, resulting in improved oil production. The method is attractive because of lower investment requirements as compared with larger field-scale flooding projects. It was previously shown both in the field and through experimental/modeling studies that nitrogen and carbon-dioxide can be used effectively in Appalachian Basin sandstones for cyclic injection in the presence of hydraulic/natural fractures. In this study, injection of mixtures of nitrogen, carbon-dioxide and methane gases is evaluated using a compositional reservoir model that represents a hydraulically-fractured, stripper-production well with characteristics of Appalachian sandstones and a 36-API gravity crude oil sample taken from the Appalachian Basin. By varying process design parameters such as injection rate, injection period, soaking period, economic rate limit and injected gas composition, 5000 simulation runs were completed to assess the applicability of the process. Results were analyzed by defining an economic indicator that takes into account discounted values of incremental oil produced, volume of injected gas, oil price and costs of injected gas for varying project periods between 1 year and 20 years. Among the ranges studied, it was observed that the process would result in a positive net present value for all the cases, up to 6 years of project time. Feasibility beyond 6 years depends on the operational parameters. Keeping the injection rate below 400 MCF/d, injection duration less than 20 days, economic rate limit below 4 STB/d and soaking period greater than 30 days would contribute to the successful application of this process. It was observed that the injected gas composition does not significantly affect the efficiency since each type of gas contributes to the recovery mechanism differently. However, economic analysis favors nitrogen since the cost of generation is lower than other gases. Results were also used to develop a screening model that is based on neural networks that forecasts the efficiency. This model was validated with 500 blind cases, with a correlation coefficient of 0.95. Analysis of this model confirmed previous findings regarding the importance of all operational parameters except gas composition.