Abstract of the Thesis

Water Management During Hydrofracking Operations of Shale Gas Fields

by

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The present work aims at developing a suitable hybrid treatment technology for treating the flowback water which is recovered during the shale gas exploration by means of hydraulic fracturing. The flowback water has been received from different wells of Oil and Natural Gas Corporation, Government of India, Gujarat. It consists of wide variety of pollutants from the fracturing fluid and the rock formation making it difficult to treat using a single technology. Thus, the whole treatment technique is divided into multiple steps for adequate and efficient treatment. Here, froth flotation has been employed as primary treatment for removing oil from the real flowback water. A first-principle based convective mass transfer model was developed to describe the froth flotation performance. The resultant equation was solved analytically, compared with the numerical solution and a parametric sensitivity analysis on the process performance was undertaken. In addition, a correlation to estimate the flotation rate constant was proposed, thereby circumventing the need to obtain a large number of cumbersome parameters experimentally. Overall, this study proposes froth flotation as an efficient primary treatment method towards the separation of dispersed oil droplets from the flowback water and corresponding prediction of kinetics, using first-principle based transport model.

The flowback water has high organic and dissolved solids. Advanced oxidation process can be used for removal of organics from the pretreated flowback water. After froth flotation, Fenton process was applied to treat this real life flowback water in order to investigate its efficacy to degrade the organics. The effects of various parameters like initial solution pH, the dose of Fenton reagents were investigated in detail. A comprehensive kinetic model was developed by considering various reactions involved in the process. The set of model equations was solved numerically and unknown rate constants were evaluated by optimization of degradation profile of the organics. The pH profile was also accurately predicted during the reaction. The model can be of help to design engineers to upscale such system.

After the appropriate pretreatment to remove oil and organics, suitable membrane system was investigated in detail to reduce the TDS. A commercial nanofiltration flat sheet membrane was used in cross-flow mode to lower the TDS of the pretreated flowback water.

Two stages of membrane filtration were carried out successfully to bring down the TDS to the desired level as prescribed by the Bureau of Indian Standards. A transient two-component gel layer controlled model was implemented for the quantification of the membrane performance for both the filtration stages. For scalability of the system, the operating parameters, cross flow rate and transmembrane pressure drop were optimized using the criteria of the minimum energy consumption.

Keywords: *Shale gas; hydraulic fracturing; flowback water; froth flotation; surfactant; Fenton process; kinetic studies; two-stage nanofiltration; TDS removal; gel layer model*