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An artificial neural network model for predicting the recovery performance of surfactant polymer floods

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Abstract

A supervised feed-forward back-propagation neural network model has been developed for estimating the recovery performance of a reservoir subjected to a surfactant polymer (SP) flood. The optimal network paradigm has been designed by conducting extensive experimentation on the proper number of hidden layers, and of neurons in each of these layers. The optimal multi-layered network topology consists of an eighteen-neuron input layer, three eleven-neuron hidden layers, and a four-neuron output layer. The network input consists of 18 dimensionless groups that critically dominate the displacement efficiency of SP floods. These groups account for the effects of surfactant slug size, polymer slug size, surfactant concentration, surfactant/oil bank mobility ratio, polymer/surfactant mobility ratio, surfactant and polymer adsorption, interfacial tension, reservoir heterogeneity, relative permeabilities, capillary pressure, waterflood residual saturations, the optimal salinity in the three-phase region, gravity, and rock wettability. Principal component analysis indicated that all of these 18 dimensionless groups were essential for scaling SP floods. The network output consists of the oil recovery at 0.75, 1.5, and 2.25 pore volumes injected (PVI), along with estimates of the breakthrough dimensionless time. The network model has been trained on a data set consisting of 499 simulations, generated using a three-dimensional compositional chemical flood simulator. Tertiary chemical floods constitute 90% of the simulation runs. The rest of the simulation cases are secondary chemical injections. The optimal network architecture was able to estimate back the oil recovery from the training set within 1.5% average absolute error. The ANN model was able to predict the oil recovery for a blind-test data-set of 125 simulated field cases within approximately 3% average absolute error. With these remarkable results, the ANN model outperformed the non-linear multivariate models available in the literature. Compared to using extensive numerical modeling based on detailed knowledge of the oil reservoir, the use of the introduced ANN model saves significant amount of time needed for the performance prediction of surfactant-polymer floods. The ANN model may, therefore, be used as a valuable tool for the preliminary assessment of oil reservoirs with respect to their suitability for surfactant-polymer flood.