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Please fill in your manuscript title.	New Polymer Rheology Models Based on Machine Learning

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Abstract

Objectives/Scope:
The objective was to develop new predictive models to predict the viscosity of HPAM polymers used in enhanced oil recovery (EOR) and implement them into a chemical flooding numerical reservoir simulator. A successful polymer-type EOR project relies upon many factors, including an adequate characterization, description, and prediction of the polymer's rheology. A high polymer viscosity can improve the mobility and sweep efficiency, but can also lead to poor injectivity. Polymers are generally non-Newtonian and the rheology is a function of in-situ shear rate, polymer concentration, salinity, temperature, molecular weight, and molecular structure. A priori estimation of polymer rheology using models is important for design of polymer floods and prediction using numerical reservoir simulators. Existing models require dozens of fitting parameters, are purely empirical, and can rarely be used for a priori estimation. Here, we develop new predictive models based on fundamentals and machine learning methods.

Methods, Procedures, Process:
We use a large database of existing experimental data for the rheology of HPAM and use a combination of fundamental, physical models and machine learning methods to develop new predictive models. The database includes the measured polymer rheology at various shear rates, polymer molecular weights and types, temperatures, and brine salinity and hardness. Some of the data also have surfactant in solution. Data are first fit to the 4-parameter Carreau model and then advanced machine learning techniques are to develop the models of the Carreau parameters with the aforementioned solution properties. The models are then used to predict the rheology of new samples which are validated against data measured on an ARES G2 rheometer. Finally, the models are implemented into a chemical flooding numerical reservoir simulator which can be used for improved modeling of chemical floods

Results, Observations, Conclusions:
As expected, all data fit the 4-parameter Carreau model well. The new models for the zero-shear viscosity, infinite-shear viscosity, shear thinning index, and consistency index are a function of temperature, polymer concentration, salinity, hardness., and molecular weight using less than ten parameters. Although, the parameters can be fit to future samples, we show that our constant parameter values can successfully predict the rheology of polymers.

Novel/Additive Information:
The new machine-learning based models are a significant advancement over existing models that have a large number of parameters, empirical, and lack fundamental basis. Inclusion of these models into reservoir simulators will lead to improved predictability of polymer EOR floods.