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Experimental and Model Studies of Fluids in Micro-Nano Scales

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Since the beginning of the 21st century, fluid flow in micro-nano space has become a new research hotspot with the rapid development of micro-mechanical systems and bio- engineer-ing. Through quartz capillary and alumina channel, the flow characteristics of gas, water and oil were explored, and the flow characteristics of unconventional oil and gas reservoirs in micro-nano scale were studied. The corresponding nonlinear flow model, non-Newtonian fluid mechanics and neural network prediction model were established, which not only ex-plains the complex mechanism of fluid flow at micro-nano scale, but also provides theoretical support for application.

(1) Experimental studies of single-phase fluid at micro-nano scale: The gas flow be-havior in micro-nano channels was studied by means of experiments, and the gas flow under different conditions was analyzed. Through the flow experiments of deionized water and oil in nanochannels, it is found that the flow characteristics of water in nanochannels are differ-ent from those in traditional macroscales. The formulae of flow rate were derived for hydro-philic fluid, and were testified by experiments of deionized water flow in silica micro-channels. Finally, the non-Newtonian power-law fluid model of single-phase liquid was derived at the micro-nano scale.

(2) Experimental studies of two-phase flow at micro-nano scale: There are three stages in the change of gas flow rate when gas drives water at the micro-nano scale. In the first stage, there is a "pinning" effect of capillary pressure at the gas-liquid interface, and the flow rate increases slowly, which is about one order of magnitude lower than that of single-phase gas flow. In the second stage, a large amount of water in the nanoarray is displaced, finally the gas flow rate increases rapidly. A mathematical model of gas-liquid spontaneous imbibition was established. The validity of the model was verified by experiments, and the formula of the minimum resistance radius was derived.

(3) Application of neural network method in tight oil reservoirs：Based on the BP neural network method, the prediction model of non-Newtonian parameters in tight oil reser-voirs was established, and the average relative error is less than 5%. Based on Adam optimi-zation algorithm, a CNN-LSTM(Convolutional Neural Network-Long Short Term Memory) neural network model was established to predict the daily oil production of fractured hori-zontal wells in tight oil reservoirs. The model fully considers the heterogeneity characteristics of tight oil reservoirs, which effectively establishes the complex relationship between reservoir parameters and oil production.

Keywords: micro-nano channels, tight oil and gas reservoirs, Single phase and two phases flow, nonlinear flow.

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