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Experimental Investigation of Non-linear Flows in Artificial Multiscale Frac-vuggy Media

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The size of the fractures and vugs ranges from micron scale to centimeter scale in frac-vuggy reservoir. And there is almost no flow in the rock matrix. Due to the multiscale of media, inertial coefficient is a key parameter to predict the correct production performances and behavior of frac-vuggy reservoirs. This paper introduced the process of making multiscale frac-vuggy media and will study the inertial coefficient of Forchheimer equation and its effect on oil-water two-phase flow in the media.

The experimental results of flow law showed that if flow rate is constant, the existence of non-linear flows for single water phase is determined by the fracture width and filling degree. And the effect of the vug can be ignored. However, for oil-water two phase flow, the fracture and vug both play an important role. Meanwhile, based on Rescaled Range Analysis(R/S), a mathematical model of judging non-linear flow is proposed. The Receiver Operating Characteristic (ROC) curve showed that it can accurately determine the flow law for oil-water two phase flow.

Through the analysis of the experimental data of non-linear flow, this paper proposed a modified Geertsma's empirical expression of inertial coefficient, which is a function of wetting phase saturation, fracture width, vug diameter, fracture porosity, vug porosity and total permeability. It's more suitable for multiscale frac-vuggy media than previous literatures reports.

The experimental results of oil-water relative flow capacity showed that non-linear flow seriously affected water and oil relative permeability curves. When the flow law transforms from linear to non-linear, the irreducible water saturation will increase, the range of water saturation where oil-water two-phase can flow together will decrease and the same relative permeability point will decrease. When the inertia increases, it will be more serious.

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