A Mechanistic Model for Oil-based Cement Slurry Flow through Fractures in Carbonate Reservoirs

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Abstract

During the life of a hydrocarbon reservoir, it is always a challenging task to curb the unwanted water production. Recently, there have been considerable interests in using oil-based cement slurry (OBCS) to prevent the unwanted water by taking advantage of its high strength and flexible selectivity. Although the OBCS has been widely and successfully utilized to mitigate water encroachment from natural fractures in carbonate reservoirs, few attempts have been made to describe its flow bahaviour in fractures. In this paper, a mechanistic model has been developed and validated to describe the oil-based cement slurry flow behaviour through fractures in carbonate reservoirs. Theoretically, the Navier–Stokes equations are integrated with the velocity equation of visco-plastic materials in a planar fracture to quantify pressure drop of the slurry flow as a function of viscosity, pressure drop, fracture width, and flow rate. Experimentally, a three-dimensional (3D) physical model is developed to simulate flow behaviour within fractures in carbonate reservoirs by using ultra-fine cement and class G cement with or without pad fluids. Pressure drops of the slurry flow are continuously monitored and recorded as a function of time during the experiments under constant flow rates and different fracture widths. Compared to the class G cement, the pressure drop of ultra-fine cement flowing through fractures is reduced by 70% when the flow distance is short, while it is slowly decreased with an increase in flow distance and finally becomes stable at 41%. Once slurry is exposed to water, its pressure drop increases rapidly and becomes one or two orders of magnitude larger, while the pressure drop has been changed from linear to exponential relationship with time. The pressure drop of ultra-fine cement is smaller than that of the class G cement during the linear stage because of its relative low viscosity, while, at the exponential stage, it is increased much higher than that of the class G cement in a short time.

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