Contribution ID: **103** Type: **Poster + 3 Minute Pitch**

Laboratory Evaluations of Fiber-Based Treatment for In-Depth Profile Control

Tuesday, 15 May 2018 16:58 (2 minutes)

Fiber-laden fracture fluid technology has been successfully implemented in unconventional reservoirs for fracture reorientation and fluid leak-off control. Inspired by the encouraging performance achieved in matrix stimulation, a new fiber-added treatment is employed for in-depth profile control, diverting injected fluids into less-permeable zones. The paper is aimed at: 1) highlighting the distinctions and connections between fracturing and conformance improvement, 2) exploring the plugging effectiveness and endurance of fiber, and 3) optimizing fiber properties to realize better compatibility with the formation.

To evaluate the fiber-laden solution, a series of experiments was designed using high-permeability sand pack models, which were equipped with 3 equally spaced pressure sensors to synchronically record the real-time pressure changes along the tube. Then, water injection, fiber injection and subsequent water injection were conducted in order. In acid fracturing, fiber fluids serve as the degradable in-situ sealant for the open mouth of fractures where high pump pressure is desirable; while water conformance control demands that the long-lasting agent be readily injected with sufficient penetration distance. Therefore, special attention is given to 3 criteria in terms of profile control: 1) inlet injectability, determined by the resistance factor (RF) during fiber injection; 2) in-depth mobility, obtained from pressure dynamics recorded along the injection direction; and 3) overall blocking effect, confirmed through the residual resistance factor (RFF) at subsequent waterflooding phase. Besides, characteristics that influence the plugging efficiency are discussed, including fiber length, fiber concentration, injection rate and injection pore volume.

After the fiber placement, the overall pressure manifestly increased yet with minor fluctuations. This behavior is explained by the particulate bridging mechanism (migration-capture-redirection-migration-recapture). All 3 sensors successively detected a pressure rise, indicating the fiber movement with adjacent permeability reduction. More specifically, farther pressure maintained at a relatively high level after subsequent waterflooding. With curled and helical structures, fibers adhered to the dispersed sand and created bridges to form a fiber cake, which was observed at the entrance and inside of the pores. It is the "wall building"phenomenon that establishes a stable fiber network and increases flow resistance. Testing results showed that the combination of greater fiber length, moderate fiber concentration and low injection rate well fulfilled the criteria. Based on the laboratory results, a "fiber number"concept was introduced to interpret the fiber movement and plugging effects, which proved to account for fiber's injectability and mobility consequently.

The fiber-loaded solution outperforms the conventional water shutoff agents for its lower price, higher plugging strength, and stronger penetrability. This treatment offers a cost-effective solution to the in-depth channeling problem. In addition, the conclusions can be used to guide the conformance control in high-permeability/fractured reservoirs for oil recovery improvement.

References

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Session Classification: Parallel 5-F

Track Classification: MS 1.01: Multi-scale Particulates Transport through Porous Media Saturated with Multi-Phase Fluids