Continuous monitoring of crude oil movement in an electromagnetic-assisted enhanced oil recovery process using a modified fiber Bragg grating sensor

ABSTRACT

The Fiber Bragg grating (FBG) sensor used for distinguishing the oil movement offers detailed insights about the reservoir oil and is the key to quantifying the impact on improvement and the integrity and efficiency of the wells. The modified FBG sensors proposed in this paper through a partially un-cladding process and magnetostrictive nanolayer coating could advantageously monitor the crude oil mobility in electromagnetic-assisted enhanced oil recovery operations. The remaining ~400 nm thickness of cladding after partial removal was coated with ~100 nm magnetostrictive Ni-Fe nanolayer. The structures of Ga-doped magnetite and Ga-doped hematite were found orthorhombic with Pnma space group and rhombohedral with R3C space group, with the corresponding remnant magnetization (retentivity) value of 94 Oe and 150 Oe, respectively. The magnetization values at 1.5 T were 30 for Ga-doped magnetite and 21 emu/g for Ga-doped hematite nanoparticles. The interfacial tension of crude oil and brine dropped for 16.9 % and 4.1 % when the Ga-doped magnetite and the Ga-doped hematite nanofluid were injected, respectively. The correlated contact angle for the Ga-doped magnetite was 65.2°, while for the Ga-doped hematite, it was 57.4°. The FBG's responses to different nanofluids and surfactant injection at the presence of electromagnetic field indicated the high sensitivity of the probe against the induced magnetic field, which was varied as a function of distance, nanofluids type, and nanoparticles accumulation near the FBG sensing point. The increase in the wavelength shift of FBG by flowing the nanofluids through the sandstone and opposite behavior was recorded by surfactant flowing. The maximum wavelength shift was 0.21 nm when Ga-doped magnetite nanofluid was injected, whereas it was 0.14 when Ga-doped hematite was injected.