Contribution ID: **759** Type: **Oral Presentation**

Validation of methodology for MMP measurements on microfluidic slim-tube analogue

Wednesday, 15 May 2024 14:00 (15 minutes)

The industry-accepted standard to define the necessary conditions for miscible oil displacement by gas is the laboratory slim-tube test, which lasts over one month and requires much fluid to be tested. This research aims to validate the results of experiments on microfluidic slim-tube analogues for the determination of minimum miscibility pressure (MMP) and propose a novel methodology to overcome the drawbacks of the traditional method. The porous structure of the microfluidic chip used in this study is represented by a channel filled with cylinders randomly distributed along it. The silicon-glass microfluidic chip and the special microfluidic platform enable working under the thermobaric conditions of the real reservoir. Mimicking real-field scenarios, the recombined live oil composition was used along with recombined associated petroleum gas. During each test, oil was displaced by gas with a minimal flow rate, whereas miscibility was determined based on the analysis of front propagation. The set of experiments was conducted at a temperature of 110 ℃ under pressures varying from 35 to 42 MPa. In total, five discrete microfluidic displacement tests were successfully performed. Additional tests that involved backfilling the microfluidic chip were done at the same pressure conditions, exhibiting high experimental repeatability. At each pressure point, displacement coefficients were determined based on the processing of experimental videos with subsequent post-analysis. The MMP value of 39.9 MPa was obtained by plotting all the experimentally determined displacement coefficients at different pressures and constructing two linear approximation lines for miscible and immiscible regimes. A comparative analysis of microfluidic and slim-tube approaches showed a relative difference of less than 5%, which proved the validity of the presented method. The proposed methodology has demonstrated its potential for accurately determining the MMP, which would have significant implications for the gas EOR projects in the fields. Each run of microfluidic experiment required less then 10 ml of recombined oil, which was more than ten times less than for an experiment on a slim-tube test. Moreover, a single microfluidic took less than half a day to complete - five times less than for a slim-tube test.

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Session Classification: MS11

Track Classification: (MS11) Microfluidics and nanofluidics in porous systems