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A Novel Method for In-Situ, Representative Measurement of Asphaltene Precipitation

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Summary

A novel method to measure a representative and downhole asphaltene onset pressure (AOP) in real time is presented. This technique combines the advantages of two standard lab techniques, the gravimetric technique, and the light scattering technique to measure downhole asphaltene precipitation. The method has been illustrated with a case study, where upper asphaltene onset pressure (UAOP), asphaltene & resin flocculation onset (AFRO) pressure, and bubble point (BP) are measured on a reservoir fluid under isothermal conditions. The results of this work have significant economic implications for flow assurance, and production from oil wells.

In-Situ Operational Workflow

The Figure 1 describes the wireline-conveyed formation tester tool string, as well as the fluid path for reservoir fluid. As shown in the figure, first a fluid is pumped out (steps 1 and 2) until low mud filtrate contamination with downhole asphaltene onset pressure (DFA) is obtained; a fluid sample is then captured with the Multi Chamber Section MCS (step 3). Subsequently, the AOP test can be performed on the reservoir fluid, which is non-intrusive to the captured sample (step 4).

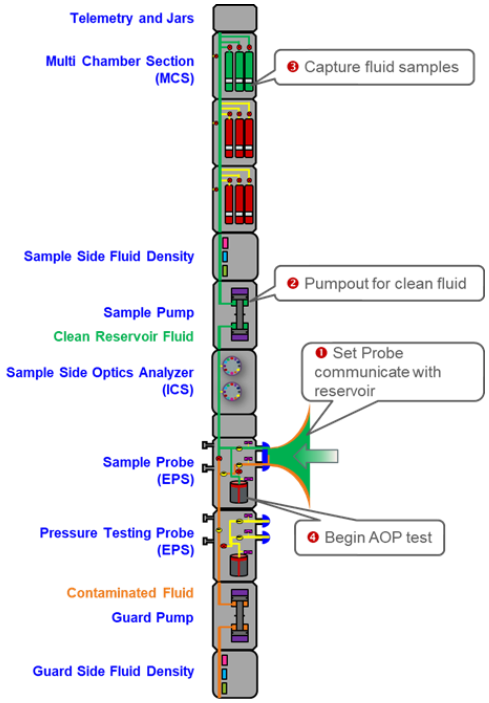

Figure 1: A wireline-conveyed formation tester was configured to perform downhole AOP measurements. The green cone and flowline signify clean oil, devoid of mud filtrate. The orange line signifies the mud filtrate contaminated fluid when configured for sampling by means of focused pump out. The numbered operations denote the sequence.

Demonstrated in a Gulf of Mexico (GOM) reservoir, this novel technique mimics the gravimetric and light scattering methods, where a fluid sample is isothermally depressurized from initial reservoir pressure; simultaneously, DFA monitors asphaltene precipitation from solution and a high-precision pressure gauge records the onset of asphaltene precipitation. The sample side optics analyzer – Integrated Characterization Elements (ICS) enables downhole fluid analysis, with real-time measurement of fluid properties and hydrocarbon components (Jones et al., 2016, 2017, and 2019); such as, methane – C1; wet gas – C2 to C5; C6+, CO2, SARA – Saturates, Aromatics, Resins, Asphaltenes; GOR – Gas Oil Ratio; color; API gravity; and water. The fluid density under flowing pressure and temperature is also measured with a high precision fluid density module.

Results, Observations, Conclusions

To augment these in-situ fluid properties measurements, additional key metrics used in flow assurance to describe the stability of asphaltenes are calculated. This includes the a) colloidal instability index (CII), and b) asphaltene solubility parameter. It is important to highlight that these measurements have not been previously calculated by the industry using DFA measurements. The rate of precipitation of asphaltenes is modeled and presented, similar to Vargas et al. (2010) modeling for their experiments. A discussion of asphaltene precipitation kinetics can help to understand the potential flow assurance problems during the production life of a well. As a reservoir begins producing (flowing pressure) at the sand face, the reservoir eventually depletes and asphaltenes begin precipitating (Figure 2). Flow assurance insights for a typical oil producing well would be described as well, to highlight various production stages and remedial actions based on information gathered from downhole in-situ AOP tests.

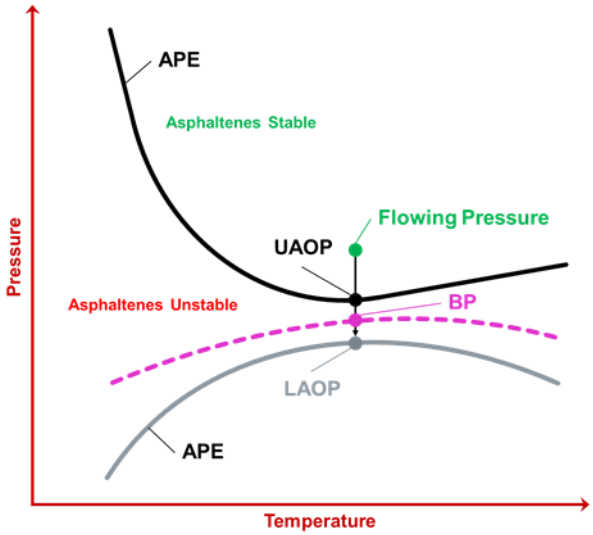

Figure 2: The asphaltene precipitation envelope (APE) denoting the stability regions of asphaltenes during production. The black line denotes the upper asphaltene boundary, while the lower gray line denotes the lower asphaltene boundary. The flowing pressure of the reservoir fluid is also marked, as it transitions from a stable asphaltenes region to an unstable region.

Novel Information

This work presents a novel method to measure accurate AOP and associated measurements at downhole conditions, while being non-intrusive to the fluid samples being captured in nitrogen-backed bottles. The measurements, and subsequent analyses can augment PVT tests to enhance the understanding of asphaltene precipitation in oil reservoirs, wells, and surface facilities.

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References

1. Jones, C., Dai, B., Price, J., Li, J., Pearl, M., Soltmann, B., & Myrick, M. L. (2019, 2). A New Multivariate Optical Computing Microelement and Miniature Sensor for Spectroscopic Chemical Sensing in Harsh Environments: Design, Fabrication, and Testing. Sensors, 19, 701. doi:10.3390/s19030701
2. Jones, C. M., Pelletier, M. T., Atkinson, R., Shen, J., Moore, J., Anders, J., Myrick, M. L. (2017, 7). A small-volume PVTX system for broadband spectroscopic calibration of downhole optical sensors. Review of Scientific Instruments, 88, 073101. doi:10.1063/1.4985545
3. Jones, C. M., van Zuilekom, T., & Iskander, F. (2016, 6). How Accurate Is Enhanced Optical Fluid Analysis Compared to Lab PVT Measurements?. Paper presented at the SPWLA 57th Annual Logging Symposium, Reykjavik, Iceland, June 2016.
4. Vargas, F. M., Creek, J. L., & Chapman, W. G. (2010, 4). On the Development of an Asphaltene Deposition Simulator. Energy & Fuels, 24, 2294–2299. doi:10.1021/ef900951n