Petroleum Research

Petroleum Research 2018(June-July), Vol. 28, No. 99. 10-14

DOI: 10.22078/pr.2017.2632.2218

Experimental Investigation of Formation Damage due to Asphaltene Deposition in Crude Oils with Low Asphaltene Content

Abbas Shahrabadi*[1], Kamran Parizad[2], Masoud Nasiri[2] and Saeed Abbasi[1]

1. Petroleum Engineering Research Division, Research Institute of Petroleum Industry (RIPI), Tehran, Iran

2. Chemical Engineering Department, Semnan University, Iran

shahrabadia@ripi.ir

Received: April/09/2017 Accepted: December/10/2017

Abstract

In this paper, a setup for performing dynamic flow experiments was prepared. A set of natural depletion tests were done to investigate the effects of pressure depletion and the initial asphaltene content of crude oils on asphaltene deposition in porous media using two live oil samples of Iranain reservoirs. The results of these experiments, which were done in constant rate and three pressure steps, show that the asphaltene deposition occurs by decreasing pressure in the vicinity of bubble point pressure and the main mechanisms are surface deposition, pore throat plugging and in some period the entrainment of the particles via the flow of oil is observed. According to the experiments, in case of the oils with less asphaltene content, the dominant mechanism is surface deposition, and the rate of deposition is uniform, while using the crude oil with higher asphaltene content, the pore throat plugging mechanism has more important role in the permeability reduction of reservoir rock.

Keywords: Asphaltene Deposition, Natural Depletion, Formation Damage, Mechanism, Asphaltene Content.

Introduction

Asphaltene deposition is one of the serious problems that the petroleum industry faces for several years [1]. Asphaltenes molecules are generally defined as the heaviest species in crude oils that are soluble in aromatics (i.e. toluene and benzene), and insoluble in n-alkanes (i.e. n-heptane). Initially, dissolved asphaltenes in crude oil can be destabilized to precipitate by varying pressure, temperature, and compositions of the oil components [2-4]. Asphaltenes are precipitated on the reservoir pore surface, and blocked them completely in some cases, which ultimately cause wettability change and formation damage [5-8]. In order to understand the mechanisms of damage, various researchers have presented various experiments and theories [9-10].

According to Wang and Sivan studies in 2005, permeability reduction is based on two mechanisms: the accumulation of fine particles in the pores and large throats, which leads to a continuous reduction of the pores surface for the fluid flow, and the plugging of the pores and throats by coarse asphaltene particles [11].

The asphaltene precipitation and deposition during carbon dioxide and light gas injection process in sandstone cores saturated with oil were studied by Bagheri et al. Also, they examined the effect of operating pressure, concentration of injected gas and production rate on asphaltene precipitation [12].

According to experimental data, modeling results and statistical analysis, Zendehboudi et al. concluded that pressure and temperature were the most important parameters in static tests, while the pressure difference (not the flowing pressure) and the temperature had more effect on the asphaltenes precipitation in dynamic tests [13].

Most of the previous studies have generally been carried out on crude oils with high asphaltene content. We used low asphaltene content crude oils in experiments. Therefore, two crude oil samples with asphaltene content of 0.5% and 0.2% were selected. The effect of pressure was studied on the amount of asphaltene precipitation in the core sample, permeability and porosity reduction.

It is necessary to note that no defined criterion exists for low asphaltene content crude oil in references.

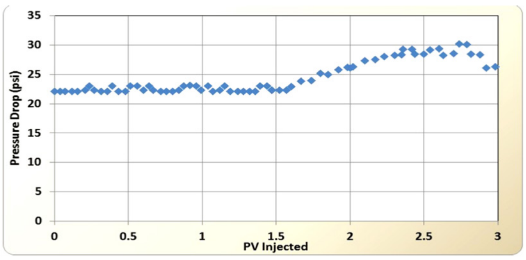
In this study, we considered asphaltene content less than 1% as low asphaltene content. It is necessary to perform tests for these oils more carefully.

Material and Experimental

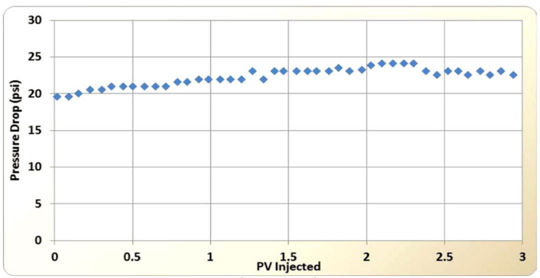
Experimental works were carried out by two low asphaltene content oil samples collected from Iranian oil fields which have 0.5 and 0.2 wt% asphaltene content and API of 33.89 and 32.87, respectively. Sandstone core of 13.44 cm in length and 0.0847 porosity is prepared for core flooding tests. A core flood system with auxiliary equipment and controlling devices designed for natural drainage dynamic tests.

Discussion and Results

Natural drainage dynamic tests have been performed at 100°C and three selected pressure (higher than the deposition pressure, lower than the deposition pressure and around the bubble point pressure). It can be concluded that large amounts of asphaltene particles are deposited in the porous medium. At pressures around asphaltene onset pressure, fresh asphaltene molecules are stripped out from crude oil. These small particles are stable in the crude oil and they do not precipitate because of sufficient resin molecules concentration around asphaltene nuclei. At bubble point pressure, asphaltene molecules can aggregate with each other and create larger size asphaltene clusters and flocculate. Once these clusters are generated asphaltene precipitation starts. The asphaltene onset pressure is 3800 psi and 3600 psi for oil sample 1 and for oil sample 2, respectively. The results of the core differential pressure are shown in Fig. 1.



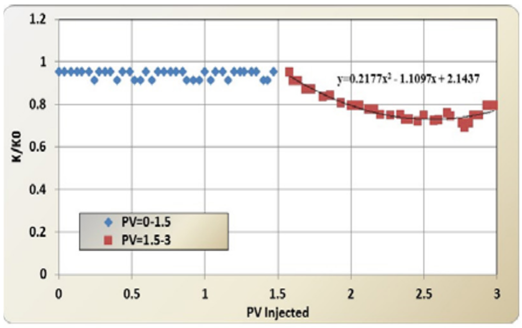
Oil Sample 1



Oil Sample 2

Figure 1: Pressure drop along the core at 3800 psi for oil 1 and 3600 psi for oil 2 respectively.

summarized into three major groups: surface deposition, pore throat plugging and entrainment of deposits. According to observations of second oil sample, the dominant mechanisms can be summarized into two parts: surface deposition, surface deposition with entrainment of deposits. In Figure 2, the permeability reduction is shown based on the pressure drop data at 3800 psi for oil sample 1 and 3600 psi for oil sample 2.



Oil 1

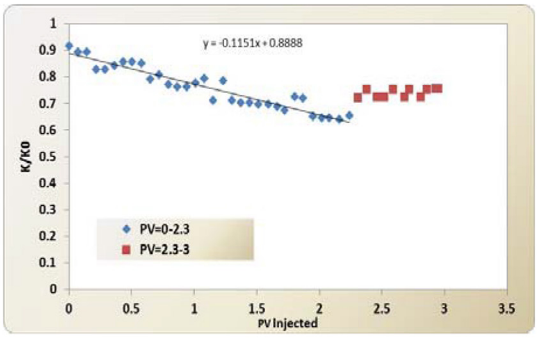


Figure 2: Permeability reduction in injection process tests.

Simultaneous activity of two different mechanisms of asphaltene precipitation is suggested based on permeability decline data (Figure 2) during injected pore volumes. During smooth permeability reduction, surface deposition is the predominant mechanism and during rapid permeability decline, both mechanisms are active.

Conclusion

We investigated the potential of asphaltene precipitation and deposition on reservoir rock during natural pressure depletion using low asphaltene content oil samples. In addition, the permeability and porosity were calculated, and the following results were obtained.

- Permeability decline was observed at injection pressures above the asphaltene onset pressure and near the bubble point pressure. It was found that by increasing the injection pressure, asphaltenes deposited on the pores of core sample which causes formation damage.

- In the case of oil with higher asphaltene content, no permeability reduction observed at pressures near the bubble point pressure at the early stages of the test. By continuing the injection, experiments showed a considerable permeability decline due to simultaneous activity of two different mechanisms of asphaltene precipitation (surface deposition, pore throat plugging).
- In the case of oil with lower asphaltene content, pressure drop is stabilized at injection pressures near the bubble point pressure and at the early stages of the test. It is due to asphaltene deposition on pore surfaces. There is a constant and homogenous deposition rate.
- Although porosity and permeability are gradually reduced during core flood tests with a same pattern, the amount of porosity reduction is small. When surface deposition is the predominant mechanism, porosity is reduced as same as permeability decline. If the deposition was considered due to the pore throat plugging, rapid permeability decline will occur, but it hasn't any effects on pore volume and porosity decrease.

References

[1]. Kawanaka S., Park S. J. and Mansoori G. A., *"Organic deposition from reservoir fluids,"* SPE Reservoir Engineering Journal, pp. 185-192, May, 1991.

[2]. Gholoum E. F., Oskui G. P. and Salman M., *"Investigation of asphaltene precipitation onset conditions for Kuwait reservoir,"* SPE 81571, Presented at the SPE 13th Middle East Oil Show and Conference, Bahrain, April 5-8, 2003.

[3]. Al-Sahhaf T. A., Fahim M. A. and Elkilani A. S., *"Retardation of asphaltene precipitation by addition of toluene, resins, deasphalted oil and surfactants,"* Fluid Phase Equilibria, pp. 194-197, 2001.

[4]. Yin Y. R., Yen A. T. and Asomaning S., *"Asphaltene inhibitor evaluation in CO_2 floods: laboratory study and field testing,"* SPE 59706, Presented at the 2000 SPE Permian Basin Oil and Gas Recovery Conference, Midland, Texas, March 21-23, 2000.

[5]. Kokabas I., *"Characterization of asphaltene precipitation effect on reducing carbonate rock permeability,"* SPE 81572, , Presented at the SPE 13th Middle East Oil Show and Conference, Bahrain, April 5-8, 2003.

[6]. Samra H. K., *"Can we ignore asphaltene in a gas injection project for light oils?,"* SPE 84877, Presented at the SPE International Improved Oil Recovery Conference in Asia Pacific, Kuala Lumpur, Malaysia, October 20-21, 2003.

[7]. Zekri A. Y. and Al-Mehaideb R., *"Steam/Bacteria to treatment of asphaltene deposition in carbonate rocks,"* Journal of Petroleum Science and Engineering, Vol.37, Elsevier, pp. 123-133, 2003.

[8]. Mohammed M. A., *"Effect of scale and corrosion inhibitors on well productiviy in reservoirs containing asphaltenes,"* Journal of Petroleum Science and Engineering, Vol. 46, pp. 243-252, 2005.

[9]. Kamath V. A., Yang J. and Sharma G. D, *"Effect of asphaltene deposition on dynamic displacement of oil by water,"* SPE 26046, Western Regional Meeting, Alaska, Anchorage, pp. 179-87, May 26-28, 1993.

[10]. De Pedroza T. M., Calderon G. and Rico A., *"Impact of asphaltene presence in some rock*

properties," SPE 27069, SPE Advanced Technology Series, Vol. 4, No.1, pp. 85-188, 1995.

[11]. Wang S. and Civan F., *"Preventing asphaltene deposition in oil reservoirs by early water injection,"* SPE 94268, Oklohamacity, Oklohama, pp. 1-16, 2005.

[12]. Bagheri M. B., Kharrat R. and Ghotby C., *"Experimental investigation of the asphaltene deposition process during different production schemes,"* Oil and Gas Science and Technology – Review, IFP Energies nouvelles, Vol. 66, No. 3, pp. 507-519, 2011.

[13]. Zendehboudi S., Shafiei A., Bahadori A. R., James L. A., Elkamel A. and Lohi A., *"Asphaltene precipitation and deposition in oil reservoirs– Technical aspects, experimental and hybrid neural network predictive tools,"* Chemical Engineering Research and Design, Vol. 92, Issue 5, pp. 857-875, 2014.