Experimental Investigation of Asphaltene content Hysteresis during Natural Depletion Process

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Abstract: Asphaltene precipitation and deposition occur in petroleum reservoirs as a change in pressure, temperature and liquid phase composition. It is great importance to investigate the asphaltene content hysteresis under change of effective factors on thermodynamic conditions such as pressure, temperature and composition. In the present work the asphaltene content hysteresis was investigated during natural depletion. Experimental procedure includes decreasing pressure from initial reservoir pressure to near saturation pressure and investigating asphaltene content hysteresis during redissolution process at reservoir temperature. At each step IP143 standard test was used to measure precipitated asphaltene. The results of the study indicated that reservoir fluid was located at unstable region. It was concluded that, above saturation pressure, asphaltene precipitation has a low asphaltene content hysteresis and pressurizing is acceptable method for solving the problem in this heavy asphaltenic crude oil. Also density measurement of flashed oil confirmed that there is a little hysteresis in asphaltene content during redissolution and precipitation processes.
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Key words: Asphaltene, Hysteresis, Precipitation, Redissolution.

1. Introduction

Asphaltene are defined as a group of crude components which insoluble in normal alkenes but soluble in aromatics [Wang et al., 2006]. Asphaltene precipitation and deposition can occur in some heavy oil reservoir during the primary depletion or gas lift process [Gong et al., 2012] and may lead to serious plugging problems. There are numerous controversial exists around nature of asphaltene [Khanifar et al., 2011]. There are two different models to describe the nature of asphaltene in solution. The first approach is solubility model which considers asphaltenes are dissolved in a liquid state. According to this model the asphaltenes in crude oil dissolve totally and uniform

solution is formed [Pfeiffer et al., 1940; Kawanka et al., 1991; Bruke et al., 1990]. The second approach is colloidal model which considers asphaltenes as solid colloidal particles which are suspended in crude oil and stabilized by large resin molecules [Mansoori, 1997; Hirshberg et al., 1984]. The validity of each model depends on asphaltene content hysteresis. Hirshberg et al., 1984 carried out experiment at 94℃ and observed asphaltene precipitation is reversible but it is very slow. Hammami et al., (2000) used solid detection system (SDS) and concluded that the asphaltene precipitation is reversible but it depends on time. According to Ashoori et al., (2005) asphaltene precipitation is completely reversible with change in temperature and it was not observed any hysteresis at this process. The aim of this study is to investigate the asphaltene content hysteresis during natural depletion by using asphaltene static apparatus.

2. EXPERIMENTAL

2.1 Setup

The schematic of the experimental setup is shown in figure 1. It contains hydraulic pump, PVT Cell, oven, high pressure metal filter, live oil cell, differential pressure gauge and sampling vessel.

A crude oil sample from one of the Iranian heavy oil was selected to study asphaltene content hysteresis. The reservoir pressure is 4500 Psia, saturation pressure of oil, 1432 Pisa, reservoir temperature 205℉ and°API of residual oil is 20.37. Table 1 includes reservoir fluid composition and SARA test results. Based on SARA analysis, Ratio of saturate/aromatic vs. asphaltene/resin was shown that reservoir fluid is located in the unstable region which means this fluid can be problematic.

2.2 Procedure

Hydraulic pump was used to transfer live oil into the PVT Cell. Then system was adjusted at specific values of pressure and temperature. After that the high pressure and high temperature filter was used to survey asphaltene precipitation. The soluble part of asphaltene was transferred to the sampler by filter. Finally with subtracting asphaltene precipitation from flashed oil under this condition from initial asphaltene content, the amount of asphaltene precipitation in PVT cell was obtained. Standard IP143 test was used to measure asphaltene content at each pressure step.

At this work the asphaltene content hysteresis was investigated under change of pressure. Firstly natural depletion test was done at reservoir temperature from reservoir pressure to near saturation pressure.

Experiment was designed at four pressure steps, 4500, 3750, 3000, 2250 and 1600 Psia. Then pressure increased in order to investigate the asphaltene content hysteresis. Secondly pressure of system was set to reservoir pressure and the asphaltene content hysteresis during both precipitation and redissolution conditions was probed. At each step density of oil was calculated by piknometer.

3. RESULT AND DISCUSSIONS

3.1 Density of oil vs. Pressure

Amount of oil density vs. pressure in both precipitation and redissolution processes are represented in Figure 3. With reduction of pressure from reservoir pressure to near saturation pressure, amount of precipated asphaltene in PVT cell decreases and therefore amount of asphaltene precipitation from flashed oil increases . Accordingly density of oil in precipitaion process decreases. During increasing of pressure at redissolution process, all amount of asphaltene precpitation don't dissolve in oil, so amount of asphaltene precipitation in PVT cell decreses and oil density increases. It was observed a little hysteresis at this process.

3.2 Asphaltene precipitation in PVT cell vs. density of oil

Figure 4 represents amount of asphaltene precipitation in PVT cell vs. density of oil during both precipitation and redissolution processes. There are good agreements between amounts of precipitated asphaltene in both directions which shows asphaltene precipitation is a reversible process. Asphaltene precipitation in PVT cell increases during precipitation process and maximum amount of it occurs at near saturation pressure point. It should be mentioned with reduction of oil density or pressure, amount of asphaltene precipitation increases and solubility theory is dominant.

3.3 Asphaltene content hysteresis during natural depletion

Figure 5 depicts precipitation and redissolution of asphaltene precipitation from flashed oil with respect to the pressure. At pressures above bubble point with reduction of pressure, amount of asphaltene precipitation from flashed oil decreases in precipitation processes. Little hysteresis is observed because the amount of precipitated asphaltene isn’t dissolve in oil during redissolution.

4. Conclusions

Asphaltene content hysteresis was investigated. Based on the experimental work at pressure above bubble point, with reduction of pressure, asphaltene precipitation in PVT cell was increased and asphaltene precipitation from flashed oil was decreased. Maximum amount of asphaltene precipitation in PVT cell and minimum amount of asphaltene precipitation from flashed oil occurred at near saturation pressure. During redissolution process, increasing pressure causes to dissolve precipitated asphaltene but not completely. There is a little hysteresis in the studied crude oil. Therefore pressurizing is a beneficial method for solving the asphaltene precipitation problems.

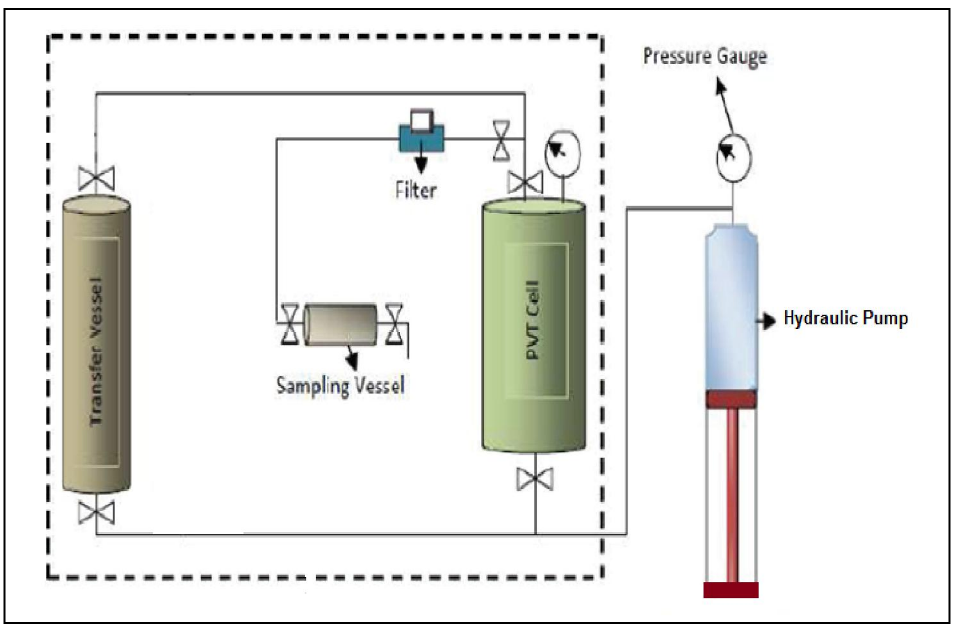

Figure1: Experimental set up used to determine asphaltene content hysteresis

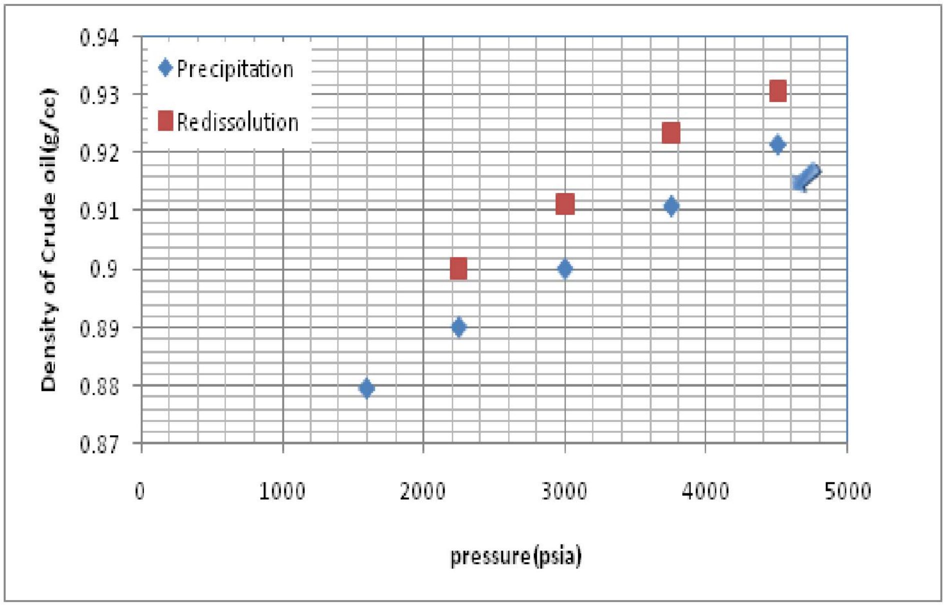

Figure 2: density of crude oil vs. pressure

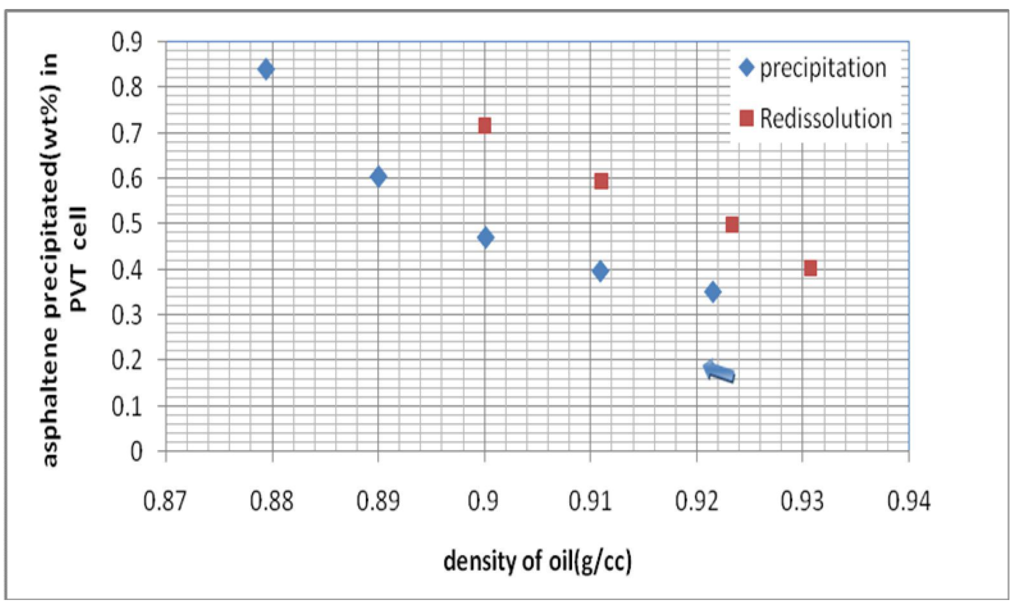

Figure3: Asphaltene precipitation in PVT cell vs. oil density

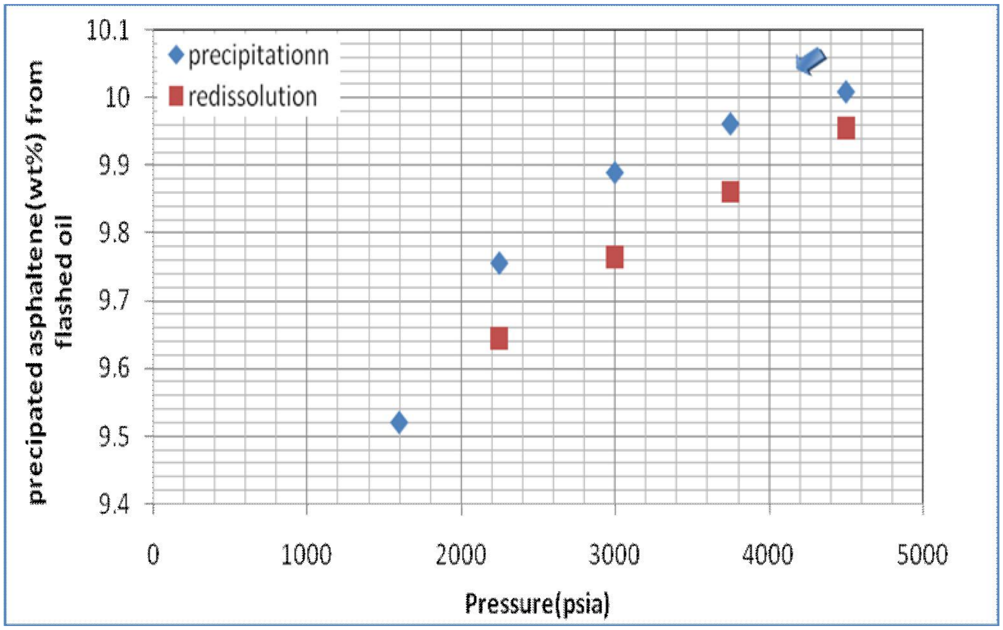

Figure 4: Precipitated asphaltene from flashed oil

Table1: Composition of crude oil and SARA test result

Component	Reservoir oil (Mole %)
H_2S	0.00
N_2	0.39
CO_2	1.74
C_1	20.55
C_2	7.31
C_3	5.34
iC_4	1.00
nC_4	3.65
iC_5	3.10
nC_5	4.75
C_6	5.48
C_7	3.23
C_8	1.32
C_9	2.27
C_{10}	2.19
C_{11}	1.81
$C_{12}+$	35.87
Molecular weight of residual oil	269
Molecular weight of C12+ fraction	370
Molecular weight of Reservoir oil	169
Sp.Gr. of C12+ Fraction @ 60/60	0.9769
Asphaltene	10.37
Resin	17.62
Aromatic	46.4
Saturate	25.61

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