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Original article

Solving asphaltene precipitation issue in vertical wells via redesigning of production facilities

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A B S T R A C T

Precipitation of heavy hydrocarbon components such as Wax and Asphaltenes are one of the most challenging issues in oil production processes. The associated complications extend from the reservoir to refineries and petrochemical plants. Precipitation is most destructive when the affected areas are hard to reach, for example the wellbore of producing wells. This work demonstrates the effect of adjusting choke valve sizes on thermodynamic parameters of fluid flowing in a vertical well. Our simulation results revealed optimum choke valve sizes that could keep producing vertical wells away from Asphaltene precipitation. The results of this study were implemented on a well in Darquin Reservoir that had been experiencing asphaltene precipitation. Experimental analysis of reservoir fluid, Asphaltene tests and thermodynamic simulations of well column were carried out and the most appropriate size of choke valve was determined. After replacing the well's original choke valve with the suggested choke valve, the Asphaltene precipitation problem diminished.

1. Introduction

Asphaltenes and Waxes are the main heavy hydrocarbon precipitations which cause the production companies to encounter with one of their most challenging problematic issues during crude oil production and subsequent related processes [1]. Although asphaltenes usually accompany with waxes in most of petroleum reservoirs, their thermo dynamical behavior, chemical structure and precipitating procedures are absolutely different. Waxes are normally soluble in middle alkanes, which are laterals and without chains consisting 18 to 80 carbons, and start crystallizing and precipitating due to temperature declining.

Based on some technical issues related to temperature in Iran's reservoir, possibility of forming wax deposition in well string is almost rare, but asphaltenes which are included up to 1 million carbons in their structures can be deposited because of aggregation phenomena. While changing the temperature and composition of crude oil cause forming of asphaltene precipitation, decrease in pressure is the most important influence factor. During production of a well where the pressure and temperature starts simultaneously declining, the asphaltene molecule precipitates and results in forming a sticky accumulation [2]. The formed precipitation in oil production blocks the well and flow lines. Subsequently, valves, separators and the wellhead facilities can lose their sufficient performance as well [3]. Even infinitesimal amount of asphaltene causes the noticeable declining in the performance of refinery and petrochemical units, catalysts and the other additives. Therefore, great efforts have been put forth to segregate these materials as much as possible [4].

Increasing the oil viscosity, declining the rate of production and enhancing the pressure losing gradient in flow lines can be resulted from the beginning of asphaltene precipitation period. While asphaltene precipitation is a consequence of thermo dynamical instability. Based on previous research it can be deduced that there is an experimental relationship between the

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concentrations of asphaltene molecules and the oil viscosity. This is because of forming a polymeric network of heavy hydrocarbons and its fast development in the crude oil [5]. Organic precipitations become very sticky and hard, if the aforementioned organic precipitations include asphaltene precipitations. This phenomenon makes precipitation of asphaltene possible in a large range of production related zone, from the porous media of well bore to the internal systems of refineries.

In petroleum upstream related industries, asphaltene precipitations are treated in 2 ways: 1) inhibiting methods 2) removing methods. The second is divided into 6 subset methods which are: 1) adjusting production related processes 2) using chemical materials 3) using external forces 4) using mechanical methods 5) thermal methods 6) using biotechnical methods. Nevertheless, researchers do believe that editing the production related procedures the best solution according to the economical, technical and environmental criteria. In fact, the other methods (2–5) are normally considered when reconstructing/designing is not possible [6].

Generally, to solve the faced problems during the production operation, cheapest and the most stable method is the adjustment of production related processes. This methods is used specifically in petroleum production connected obstacles such as precipitating, two-phase flow, decline of production rate and etc. It means that it must be tried as mush as possible to prevent entering the produced oil to the thermo dynamical zone asphaltene precipitation. Shear reduction, removing incompatible materials from the current of precipitator crude oil, decreasing the trend of pressure reduction in production facilities, preventing from the mixture of precipitator and inhibitor of crude oil in production unit and neutralizing the electro statistical forces existing in pipes are the 6 ways of redesigning/reconstructing the production related processes [7].

To inhibit forming precipitations in the well string and by regarding the existing components within the crude oil, the thermo dynamical conditions of production related processes must not overlap with the thermo dynamical zone of pipes, temperature figure and onset pressure of asphaltene forming [8]. In the same conditions of production, if the figure of asphaltene in crude oil is blue, the oil will not enter to the asphaltene forming zone, from the beginning to the end of fluid movement in the well string. But, it is not a true story about the oil with the about the oil with the red figure of asphaltene forming (See Fig. 1). The production group of Arvandan Oil Company has put forwarded a method of adjusting the production related processes in Darquain light oilfield in order to prevent any asphaltene precipitation. Firstly, they examine the thermo dynamical behavior of the supposed oil and then, plot its phase diagram

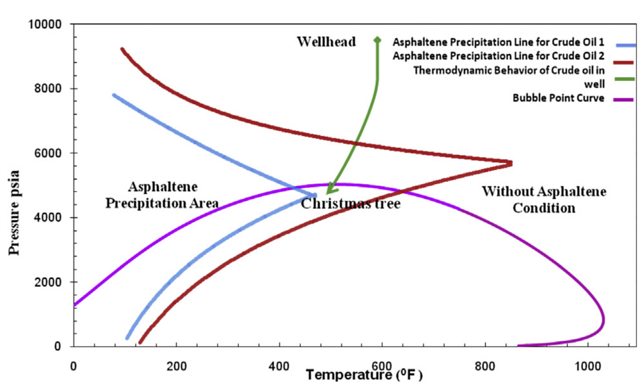

Fig. 1. Asphaltene Deposition Envelope (ADE) for two oil samples and the production range during the well.

based on pressure and temperature. After that, the relationship among the amount of deposition, pressure and temperature was correlated according to the plot of ADE through using the WinProp and PVTi software. The possibility of asphaltene forming was analyzed through running a sensitivity analysis for pressure, temperature and different chock sizes, 22/64, 32/64 and 42/64 inches.

2. Determining the thermodynamic behavior of implemented crude oils and asphaltene precipitations in Darquain oilfield

The Prosper software was used to meet the goal which was selecting the best chock size by applying the material balance for the produced precipitations through paying attention to the production data of well No. 10 for the last 8 years. Applying the optimized chock size has resulted in blocking the production of asphaltene precipitations. Knowing the thermo dynamical behavior of the asphaltene molecule and the sample of the produced crude oil is an important principle to understand completely the problem of asphaltene precipitation in oil wells which is normally happened in both light and heavy oil [9]. One of the samples gained from the Darquain oilfield which is highly probable to precipitate asphaltene has the fluid properties of 37.5° API, 0.33 cp, 4285 psia and 2115 ft^3/STB for gravity, viscosity, bubble point pressure and solution gas; respectively. Asphaltene concentration in the supposed sample is 0.22 mol percent (2.69 weight percent). To know deeply the thermo dynamical behavior of the supposed sample a group of expansion testing phase were run which different parameters such as changing volume, associate gas and formation volume factor were tuned in PVTi software. The generated results indicate the high level of accuracy existing in the software (See Fig. 2). After concluding the reliability of simulated data, the phase diagram of the live oil sample was plotted (See Fig. 3).

Because asphaltene precipitations exist in the supposed oil sample, determining asphaltene percent, asphaltene onset pressure and the other hydrocarbon components such as the aromatic, the saturated, the resin, and asphaltene through SARA test is inevitable. Observing the effect of temperature on precipitation forming is the most prominent tip due to existence of 2 opposite behavior about light and heavy oil [10]. Increasing the temperature in light oil results in the reduction of deposition while it is somehow vice versa in heavy oil. Based on SARA data (Asphaltene 2.69%, Resin 3.29%, Aromatic 19.73% and Saturates 74.28%) and plotting De-Bore figures, ratio of asphaltene to resin, colloidal instability index, asphaltene stability index, it was concluded that the oil samples is precipitation former. It has been depicted in Fig. 4.

The filtration experiment for HPHT condition and the High Pressure Microscopy test were run to determine the quality and quantity effects of pressure and temperature on precipitation forming. The experiments reveal this fact that reducing the pressure until bubble point in isothermal condition causes increasing the amount of asphaltene precipitation, but continuing the downward trend of pressure; the amount of asphaltene deposition starts decreasing. Up and down points of deposition envelope are (2300 and 7300 psi) in 290 °F. In the other hand, reducing the temperature causes increasing the amount of produced deposition [11]. Fig. 5a shows lab outputs of observing the effect of temperature and pressure on asphaltene precipitation forming.

Through overlapping the Figs. 3 and 5a, it becomes possible to plot the asphaltene deposition envelope which plays a leading