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MODELING OF CARBONATE PETROLEUM RESERVOIRS

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Abstract- **Carbonate deposition in oil reservoirs affects oil wellbore performance. In this paper, influence of asphaltene deposition in low permeability oil reservoirs performance including two-phase flow of water and oil is studied. The experimental dataof water and oil relative permeability represented in the literature and dataof capillary pressure using network modeling calculated by the authors are applied. In order to simulate oil reservoir, a three-dimensional, three-phase black oil simulator is used. The study includes twoparts of oil production well with controlled oil rate and controlled bottom hole production well pressure.**

I. INTRODUCTION

Asphaltenes are defined as “the wax-free fraction of crude oil that is insoluble in n-heptane but soluble in hot toluene/benzene” (ASTM 6560). Asphaltenes can precipitate due tochemical and physical alterations of oil such as injecting low surface tension fluids including light paraffins, gas condensates, changes in PH and drop in the reservoir pressure. Mousavi-Dehghani et al. (2004) have demonstrated that up to seven distinct phase transition points due to heavy organics from petroleum fluids can be identified. They analyzed the existing experimental methods for determination of the onsets of asphaltene phase separations and showed that these techniques measure onset of different phase separations due tochanges in the conditions of oil. Also, Riazi (2005) has presented a review of the thermodynamicand physical properties, as well as thermodynamic models of organicprecipitation including asphaltene. Despite many experimental researches performed on porous media, minor works are conducted on the subject of mathematical modeling of formation damage. The use of these models in actual reservoir analysis has been limited due to the difficulties in understanding and implementing these models.

Relative permeability and capillary pressure curves define oil recovery. They depend on the geometry and topology of porous mediaand physical properties of fluids. Studies show that in conventional models relative permeability and capillary pressure are calculated based on empirical correlations with nophysical basis. It is assumed that capillary pressure and relative permeability are only functions of saturation and are independent of fluid properties. However, these assumptions provide inaccuracy in the oil recovery results.

In this study, the influence of asphaltene deposition on UAE carbonate oil reservoirs with low permeability including two-phase flow in imbibition displacement is assessed. For this purpose, the calculated capillary pressure using network model calculated by the author Nasri (2008) and experimental data including oil and water relative permeability represented by Shedid (2001) are incorporated intoa three-dimensional, three-phase, black oil simulator, BOAST, provided by US Department of Energy.

II. MODEL

Ali and Islam (1997, 1998) studied the effect of asphaltene deposition on carbonate rock permeability in single-phase flow. Two distinct mechanisms were considered: deposition and adsorption. A mathematical model is coupled to deposition and adsorption mechanisms and the results are compared to experimental dataof carbonate rocks. They suggested hypothetical division of porous medium intopluggable and non-pluggable pathways. The pluggable pathways are of smaller pores that can be completely plugged. On the other hand, the non-pluggable pathways cannot be completely plugged and the pore throat diameter is reduced resulting from solid deposition. The model has many adjustable parameters.

Minssieux et al. (1998) studied the flow properties of several asphalteniccrude oils at reservoir temperature in rocks of different morphology. The PARticle Injection Simulator (PARIS) model developed for solid colloidal particles have been used topredict the effect of asphaltene deposition. The single-phase flow is modeled.

Leontaritis (1998) developed a simplified model for prediction of formation damage and productivity decline by asphaltene deposition in under-saturated conditions. The flow is assumed radial. The porous media is considered as a bundle of tortuous flow tubes. The mean hydraulic diameter is estimated by the ratioof the total pore volume to the total pore surface areaof the flow channels.

The network models in two-phase flow are applied topredict capillary pressure, relative permeability and oil recovery. There are two types of immissible displacement processes in porous media: drainage and imbibition.

In drainage the non-wetting fluid displaces the wetting fluid and in imbibition the wetting fluid displaces the non-wetting fluid. The mechanisms of these two displacements are completely different. In drainage capillary pressure is increased. This displacement is slow and the only mechanism is piston-type.

In imbibition the wetting fluid invades and displaces the non- wetting fluid. The mechanisms in imbibition include piston-type, snap-off, and pore-body filling.

The saturation of the desired phase and the conductance of each pore and throat for that phase are determined.

In this paper, the network modeling is applied topredict capillary pressure in imbibition. The pore and throat size distribution is obtained by using petrophysical properties of reservoir and the experimental dataof capillary pressure in drainage mechanism. The network model proposed by Blunt (1997, 1998, 2001), Blunt et al. (2002) and Patzek (2001) is modified topredict asphaltene deposition effects on petrophysical properties containing absolute permeability, porosity, throat and pore size distribution, also its effect on two-phase fluid flow including capillary pressure and water and oil relative permeability in drainage and imbibition. Optimization of the networks is performed by applying truncated Weibull function, a statistical distribution function (Weibull, 1951). The cross-section of 92.6% of the elements is triangle, 6.51% is square and 1.23% is circular.

Toassess the model, the experimental dataof low permeability carbonate core samples reported by Shedid (2001) is applied. Acomparison between the changes in porosity and absolute permeability shows that asphaltene causes more permeability damage than porosity reduction. The asphaltene induced damage is considered by two mechanisms; the smaller throats are plugged owing to large asphaltene particles and the larger throats diameter is decreased. In imbibition which occurs after drainage, oil pressure is constant and water is injected from inlet and the capillary pressure decreases. The capillary pressure in imbibition is predicted using network model. Topredict the asphaltene influence on well performance and oil reservoirs during oil production in imbibition, the experimental dataof oil and water relative permeability and calculated capillary pressure using network model is applied.

III. CONCLUSIONS

Asphaltene deposition influence on oil reservoir performance in imbibition displacement is studied.
The main results of this study are as follows:

1. The maximum average reservoir pressure is approximately similar in different cases of asphaltene deposition.
2. The difference between the bottomhole pressures at water injection well and oil production well is increased owing to increase in the amount of deposited asphaltene.
3. With the increase in the amount of deposited asphaltene, the bottomhole pressure at oil production well is decreased.

4. The average pressure of reservoir increases while asphaltene deposition is raised.
5. In part 2 the rate of oil production at the beginning of the process is constant with the increase in asphaltene deposition, but after a long time it is more in case of more porosity.
6. Increase in the quantity of deposited asphaltene and conse- quently decrease in absolute permeability of porous mediacauses the bottomhole pressure at water injection well to increase.
7. The total amount of produced oil is decreased with the increase in deposited asphaltene.

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