IFP - OAPEC Joint Seminar ***"Improved Oil Recovery (IOR) Techniques and Their Role In Boosting The Recovery Factor"*** **Rueil-Malmaison, France, 26-28 June 2007**

Productivity & Injectivity Enhancement

Current Status and New Challenges for IOR

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1. Introduction

World energy demand is projected to increase at about 1,8%/year between 2000 and 2030 and will continue to be dominated by fossil fuel with the oil as the main source (34%)[1]. To sustain this rapid growth, boosting hydrocarbon reserves through E&P in challenging environments will not be sufficient. The key boosters will be the mature field that already account for 70% of world's production but with a common recovery factor under 35%! Thus, producers are currently driven to improve returns from their mature assets looking for ways to enhance the recovery factor and arrest productivity decline. EOR methods have been known for decades but low oil prices and old technology limitations, poor reservoir characterization and often an inadequate understanding of the process itself[2] have hindered implementation of many projects. Coupled with today's trend in oil prices and complying with environment constraints, IOR concept that combines advanced EOR techniques, improved reservoir and well management and better production technologies will play a key role in significantly improving the recovery factor of mature field.

Within the IOR concept, wellbore management in general and well productivity and injectivity enhancement in particular is a key issue. This is a crucial aspect in mature fields that are highly depleted and produce at high water cut. The near wellbore region is the critical, but often the "missing" link between the reservoir and the well. Numerous phenomena take place in this area all along the well production life and become more and more complex with filed maturity. Understanding, modeling and integrating these phenomena according to IOR concept before field implementation of any EOR project is a perquisite to meet success.

In this presentation, the nature of near wellbore phenomena and their impact on well productivity/injectivity will be first reviewed together with the current treatment solutions applied for productivity enhancement. Then, some new challenges associated with the advanced EOR method will be highlighted with the main emphasis on asphaltenes, emulsion and produced water issues.

2. Key Features

In almost every EOR operation there are potential sources of damage to well and impeding its productivity/injectivity. As the fluids used in recent advanced EOR methods are more and more complex, the sources that could have a huge negative impact on well performances are increasing especially in mature fields. During the presentation, we will consider and discuss the following aspects:

Emulsions issues

Generation of stable and tight emulsions during oil production and their impact on productivity/injectivity is now recognized as a major technical issue [2, 3]. The key areas of concern are:

- Viscosity increase
- Oil-water separation
- Impact on the recovery factor
- Chemical reuse
- Productivity/injectivity

The key features to be discussed are how and where emulsions are generated, how and when emulsions could impact productivity and injectivity and how do we appraise and mitigate this impact.

Asphatene issues [4,5]

Asphaltene precipitation/deposition takes place everywhere in the production system from reservoir (heavy oil extraction methods, CO2-flooding, acidizing) to tubing and surface facilities through near wellbore area. For mature field, and due to reservoir depletion and high water cut, asphaltene deposition is mainly a near wellbore phenomenon with severe well productivity loss as a consequence of wettability alteration, permeability reduction and emulsion stabilization. This important issue will be discussed with the main emphasis on:

- Predictive action through advanced physical modeling
- Productivity enhancement through the development of prevention and mitigation means and processes.

Injectivity during PWRI and CO2 flooding [6,7]

Finally and with respect to the mentioned issues, productivity/injectivity enhancement challenges in some EOR operations such as PWRI (produced water re-injection) and CO2 flooding will be discussed. PWRI is an important option in productivity enhancement through a PWM (Produced Water Management) strategy. It simultaneously allows converting waste to value and preserving the environment. The injectivity issue during PWRI, as related to water quality, reservoir characteristics and re-injection conditions, will be addressed and discussed. Regarding CO2-EOR, and despite the gained experience, the interactions between the injected CO2 and reservoir rock and fluids have not been well studied and understood. Project management and economics often suffers from a lack of well injectivity and productivity appraisal. Among the main factors that are likely to impact well productivity/injectivity during CO2-flooding, the following will be highlighted during the presentation: CO2- reservoir rock interactions, multiphase flow and CO2-oil interactions.

3. Conclusions

The main conclusions of the presentation are:

- Understanding near wellbore phenomena is a key issue in productivity/injectivity enhancement. In spite of their key role in determining well and reservoir performances, little attention is paid to these phenomena and moreover, most of the time, they are not properly integrated in the reservoir management efforts.
- For the new EOR projects to meet success, better understanding of the processes involved is required through sustainable R&D work. The impact on well productivity/injectivity of the complex fluid used or generated should be properly and comprehensibly evaluated in order to reliably forecast the performance and efficiency of an EOR project.
- To deal with near wellbore phenomena, there is an urgent need of an integrated approach including a strong interaction between laboratory investigation, physical modeling, on-site and pilot testing. The ultimate objective is to develop a near wellbore model with advanced physics that was, and still is, the "missing link" between the reservoir and the well.

4. References and Bibliography

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5. Speaker's Biography

Lahcen Nabzar holds MS degree in Chemical Engineering from the "Ecole Nationale Supérieure des Industries Chimiques", ENSIC, Nancy, and a Ph.D in Polymer Physics from the University of Strasbourg. He joined IFP on July 1998 as a senior research Engineer in the Reservoir Engineering Direction, Petrophysics Department. He conducted research on colloid transport in porous media for more than 10 years with the aim of elucidating the physics of complex reservoir fluid flow in the near wellbore area and of their impact on the productivity and the injectivity of wells. He has authored and co-authored 27 papers and gave several presentations at international meetings and conferences. Currently, he is the project leader of "Produced Water Re-injection: PWRI" and "Asphaltene Deposition" projects. Both activities include experimental, theoretical and modeling aspects aiming at developing an integrated approach of productivity/injectivity loss issues. This approach includes damage evaluation, characterization and physical modeling together with the development of innovative products and processes for productivity and injectivity enhancement.