An update on the developments in petroleum production research in Brazil

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Abstract

The first special issue of the Journal of Petroleum Science and Engineering devoted to petroleum production research in Brazil [Journal of Petroleum Science and Engineering, 2001. 32 (2–4) (29 December)] was published in December 2001; guest editors of that issue were Prof. Rahoma S. Mohamed, Prof. Denis J. Schiozer and Prof. G. Ali Mansoori. In the Introductory paper to that special issue [Mansoori, G.A., Mohamed, R.S., Schiozer, D.J., 2001. \textit{An introduction to petroleum production research in Brazil}. Journal Petroleum Science and Engineering 32 (2–4), 73–77, (29 December)] the historical background and the status quo to petroleum production and research in Brazil were reported. What is reported here is an update on the developments in petroleum production activities and research in Brazil.

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1. Introduction

In July 1997, the Government of Brazil approved the full text of the Brazilian Petroleum Investment Law. At that time, the potential allocation of funds obtained from petroleum royalties on scientific and applied research in the field of petroleum engineering was expected to have significant impact in this area. In recent years petroleum production and research has changed due to the consolidation of Agência Nacional do Petróleo (ANP) and its role in the national scenario.

Proved petroleum reserves in Brazil (Fig. 1) rose from 8.15 billion barrels in 1999 to 8.5 billion barrels in 2001 and then to 10.6 billion barrels in 2003, while petroleum production has increased from 1.132 million barrels per day (b/d) in 1999 to 1.295 million barrels of oil per day in 2001 and to 1.55 million barrels of oil per day in 2003. In this sense, both Brazil reserves and production have increased much more rapidly than the world average increases in this period.

A chronological summary of petroleum production and consumption in Brazil is shown in Table 1.

According to Table 1 Brazil had to import about 44% of the petroleum it consumes in 1990, which had a significant adverse impact on its economy. In 2002 the share of importation of petroleum reduced to about 18%.
While petroleum consumption in 2002 was up 47.5% from 1990 (1.466 to 2.162 million b/d), imports of crude and refined products in 2002 decreased 33.5% from 1990 (645,000 b/d to 429,000 b/d). Argentina, Saudi Arabia, and Venezuela are Brazil’s main suppliers of petroleum and petroleum derivatives.

With the significant increase in its domestic production Brazil is reaching closer to self-sufficiency in petroleum production.

Recent advances in petroleum production and exploration in Brazil are a result of considerable effort by PETROBRAS in order to face the current challenges in deep and ultra-deep water environments, heavy oil production and HPHT reservoirs, and important scientific and technological developments have been attained in the classical areas of reservoir, production, drilling and completion engineering.

2. This special issue

This special issue is organized as a posthumous homage to Dr. Rahoma Sadeg Mohamed, Professor of Universidade Estadual de Campinas (Campinas State University), in Brazil, and a member of the Editorial Board of the Journal of Petroleum Science and Engineering. It comprises twelve papers, out of seventeen original contributions received in response to a call for papers.

The first two papers are related to core-flow oil transportation and have Prof. Mohamed as co-author; in both of them the problem of possible accumulation of oil in the inner pipeline surface is addressed. The first one, entitled “Contact angle measurements and wetting behavior of inner surfaces of pipelines exposed to heavy crude oil and water” and authored by Santos, Mohamed, Loh and Bannwart, presents an investigation of the interaction between polar oil components and solid surfaces. The authors demonstrate that the observed wettability alteration in commercial and galvanized steel surfaces can be ascribed to the presence of asphaltenes and naphthenic acids; however, the use of 1% sodium metasilicate aqueous solution can prevent this change in wettability. The second paper, authored by Silva, Mohamed and Bannwart and named “Wettability alteration of internal surfaces of pipelines for use in the transportation of heavy oil via core-flow,” examines the modification of pipeline inner walls in order to minimize heavy oil adherence. The authors analyze both a chemical modification, through the oxidation of the surfaces, and a mechanical modification, through the alteration of surface roughness. The effectiveness of the studied procedures was also verified by contact-angle measurements, and controlled surface oxidation was found to be a promising alternative.

The third paper is entitled “Inhibition of asphaltene precipitation in Brazilian crude oils using new oil soluble amphiphiles” by Rocha Junior, Ferreira and Ramos. In this paper, besides traditional amphiphiles considered for comparison reasons, the authors studied the effect of some vegetable oils (such as coconut essential oil, sweet almond, andiroba and sandalwood oil) and organic acids (such as linoleic, caprylic and palmitic acids) on asphaltene precipitation and asphaltene solubilization capacity in aliphatic solvents. While vegetable oils appear to be an interesting alternative to be considered, organic acids did not perform well. Once these organic acids are constituents of vegetable oils, the results suggest that fractionation of these oils may lead to more efficient additives.

The paper “Measurement and modeling of methane dissolution in synthetic liquids applied to drilling fluid formulation for deep and ultra-deep water wells” by Ribeiro, Pessôa Filho, Lomba and Bonet presents new experimental data and thermodynamic modeling of the solubility of methane in three kinds of synthetic fluids: a normal-paraffin mixture, a (normal+iso)-paraffin mixture, and a ester mixture. Due to environmental restrictions, these synthetic fluids may be the only option when drilling high-temperature and high-pressure wells; therefore, relevant aspects concerning kick occurrence and detection were analyzed: bubble point pressure, solubility, oil formation volume factor, gas formation volume factor and liquid density. However, the results for methane solubility and oil formation volume factor did not indicate a conclusive standpoint on which kind of synthetic fluid would be more adequate.

The next four papers are related to the modeling of phase equilibrium and transport phenomena relevant to
petroleum production. The first one of them is “Accurate prediction of clathrate hydrate phase equilibria below 300 K from a simple model,” by Zhang, Debenedetti, Prudhomme and Pethica. Although this paper is not directly related to Brazil, it is included in this special issue because of its homage character. The authors present a model combining a modified van der Waals-Platteeuw model to describe the fugacity of water in the hydrate phase and the Peng–Robinson equation of state to model hydrocarbon and aqueous phases. Although simple, with only two adjustable parameters, the model was shown to be able to correlate phase equilibrium data for several guest molecules (hydrate-forming) to within experimental uncertainty. According to the results obtained, calculations are insensitive to the solubility of these molecules in water. This paper is followed by “A splitting technique for analytical modelling of two-phase multicomponent flow in porous media” by Pires, Bedrikovetsky and Shapiro, wherein the authors present a mathematical solution for one-dimensional models for two-phase enhanced oil recovery. By a judicious choice of coordinates, the authors were able to split the equation set into an auxiliary system, containing only thermodynamic variables, and a main system, containing both hydrodynamic and thermodynamic parts. Therefore, phase equilibrium can be calculated beforehand using the auxiliary system, which does not depend on transport properties of the fluid, thus greatly simplifying the solution. This new possibility of EOR models presents a tantalizing field for further investigations. The next paper is entitled “Correction of basic equations for deep bed filtration with dispersion” and is authored by Altoé Filho and Bedrikovetsky. The authors propose a model for deep bed filtration that accounts for particle dispersion, which is a question of significance when considering water injection in offshore production. The effect of particle dispersion is expected to be important near to wells, and in fact the authors conclude that accounting of it does improve the performance of the model when compared to experimental data. Finally, the modeling of heat transfer phenomena that occur during acidizing operations is presented in the paper “Thermal analysis in matrix acidization” by Medeiros Jr. and Trevisan. The methodology used by the authors considers transients both down the wellbore and within the reservoir itself — in this later case, also considering the heat generated by chemical reactions. The complete temperature profile is subsequently calculated by coupling both solutions, providing a comprehensive model of an operation used worldwide.

The next two papers present algorithms aimed at helping the process of decision taking when planning and managing offshore production. The paper by Carvalho and Pinto, entitled “An MILP model and solution technique for the planning of infrastructure in offshore oilfields” investigates strategies for optimal location of platforms, assignment of wells and production of oil and gas. Based on a series of simplifying but realistic assumptions, the authors developed a mixed integer-linear programming to describe the problem, subject to constraints that include economical factors (such as cost of drilling and connection) and technical factors (well pressure drop on extraction). The solution of the problem requires a significant amount of computational time, and different solving strategies were tested, but it was possible to get solutions even for large numbers of wells. The next paper is “Characterization of operational safety in offshore oil wells” by Miura, Morooka, Guilherme and Mendes. The authors propose the use of Quantitative and Dynamic Risk Assessment (QDRA) to quantify the safety level in oil wells through the identification of safety barrier integrated sets. With this quantification, safety analysis can be carried out when planning an intervention. Computer programs developed in order to systematize the analyses are also presented.

The rapid analysis of crude oil samples, a crucial problem concerning Brazilian petroleum production, is the theme of the paper by Falla et al., “Characterization of crude petroleum by NIR”. The authors investigate the possibility of relating near infrared spectral data to simulated distillation curves: the relationship is established through a neural network model for forty petroleum samples with API grades from 31.1 to 36.4. A significant correlation was obtained, which indicates a great potential of using this technique when analyzing oil samples.

The last paper is not strictly related to petroleum production and reservoir engineering; however, it is published herein both because of the homage character of this issue and because it may be relevant to some aspects of petroleum production either by analogy or by extrapolation. The paper by Souza et al., entitled “Predicting coke formation due to thermal cracking inside tubes of petrochemical fired heaters using a fast CFD formulation,” presents a computational study of thermal cracking of heavy petroleum residues. Temperature, velocity and composition profiles were obtained for both laminar and turbulent flow, and the conditions for coke formation are analyzed. Concerning petroleum production, this paper presents a procedure that can be extended to other reservoir
problems, such as asphaltene precipitation and matrix acidization.

Acknowledgments

We sincerely hope that this issue presents the same high level that we are used to see in this Journal.

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