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Evaluating Transient Multiphase Model Performance for the Brazilian Offshore Environment

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Abstract

The use of multiphase transient flow models in pipes by PETROBRAS has increased since the early 90's. Most of its motivation came from the need for more accurate analysis of transient operations that naturally take place in offshore activities, such as gas-lift well startup and boosting techniques under intermittent flow. During the first years, the dynamic multiphase flow models were mainly used for providing qualitative analysis and had relatively little influence on project decisions. In the forthcoming years, the development of new deepwater fields in low temperature environment has brought the need for more sophisticated pressure and temperature predictions. In this scenario, the use of the complex and comprehensive transient multiphase models has become mandatory to mitigate risks in the development projects. Situations such as severe slugging, wax deposition, hydrate formation, shut-downs and start-ups are examples of transient multiphase flow conditions that must be fully evaluated and understood for a sound engineering design and safe operation. One of the key issues in using the available transient codes, either commercial software or in-house models, is the confidence in the results they generate. In order to validate the models, one needs to rely on the comparison of the theoretical predictions against experimental data, from both, laboratory and field. PETROBRAS has been making efforts in building a data base to allow field validation of the used models, despite the difficulties in obtaining reliable and good quality field data. This work aims at describing the experience accumulated in applying a commercial model to design and trouble shoot operations under steady and transient multiphase flow conditions in the Campos Basin. The model strengths and weaknesses, as currently seen by their users at PETROBRAS, based on the limited available field data, will be shown.

Introduction

Subsea wells, manifolds and floating production units have been widely used in the Brazilian offshore production systems since the 1970's. Presently, the offshore fields share represents nearly 90% of the total oil production. Especially during the last years, oil and gas production from deep and ultra deep waters has increased considerably, mainly in the Campos and Espirito Santo basins. In this typically low temperature scenario, the acquisition and prediction of values for pressure, temperature, flowrates, holdup etc., are essential to the reservoir management and safety of the operations. Thus, in the absence of reliable information, even the most ordinary operational problems become difficult to interpret and wrong decisions may be implemented. That may be particularly true in situations involving startup and shutdown operations, in addition to some others that may lead to pipe blockage.

Transient multiphase flow models – and their computational implementation – are important tools to predict operational problems, other than conceiving and testing mitigating procedures. They are available as commercial tools or as companies' in-house codes developed for specific applications. In order to evaluate the closeness between models and field data, three history cases were analyzed. The field data are compared the numerical predictions for ordinary operations involving shutdown, startup and pigging.

Caratinga field

The offshore Caratinga field, uncovered in 1994 and producing since 1997, broadens through a water depth from 850 to 1350 m and is located around 100 km offshore. The production comes from a gas-in-solution reservoir, having the pressure maintained by water injection and gas-lift as the artificial lift method. Since 2005, it has been exploited by a FPSO (Floating Production Storage and Offloading) anchored at a 1040 m water depth and connected to 12 producing and 8 water injection wells. Most of the wells are outfitted with downhole and wellhead pressure and temperature gauges.

Shutdown

The operation subject to this analysis is a well shutdown caused by preventive maintenance needs in the FPSO. The natural flowing well CRT-28 was selected as the most suitable to analysis due to the availability of reliable downhole and wellhead pressure and temperature information in the SCADA system. Additionally, a conventional production test had been carried out just a few days before the shutdown in such a way