NEW TOOLS FOR OIL AND GAS RESERVOIR FLUID MANAGEMENT

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NOUVEAUX OUTILS POUR LA GESTION
DES GISEMENTS DE PÉTROLE ET DE GAZ

Cette communication constitue un bref survol de l'état de l'art dans le domaine de la gestion des fluides dans l'industrie pétrolière, ainsi que des besoins en recherche induits par les nouveaux défis de l'exploration.

NEW TOOLS FOR OIL AND GAS RESERVOIR FLUID MANAGEMENT

This paper is a brief review of the state of art in the field of fluid management in the petroleum industry, as well as of the research needs resulting from the new exploration challenges.

NUEVAS HERRAMIENTAS PARA LA GESTIÓN
DE LOS YACIMIENTOS DE PETRÓLEO Y DE GAS

Esta comunicación constituye un breve resumen del estado de la técnica en el campo de la gestión de los fluidos en la industria del petróleo, así como de las necesidades en cuanto a investigación, que se derivan de los nuevos retos de exploración.

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INTRODUCTION

In the petroleum industry, the number of new exploration and production projects increase rapidly. All the companies are looking for new exploration areas and for lower production costs of their fields. Consequently, the reduced number of fluid specialists are now facing an increasing number of challenges:

- Extension of the pressure and temperature domain: higher depth means higher pressure and higher temperature, deep offshore means low temperature under high pressure.
- Quick look to new opportunities implies new tools for the estimation of fluid properties on the basis of very scarce data.
- Bidding for a new project is possible only if the uncertainties on fluid composition have been precisely evaluated, extension of the fluid composition to the whole reservoir supposes that all the thermodynamic forces are taken into account.
- Building reliable development projects needs integrated engineering studies with a consistent adaptable fluid model.

Some practical solutions have been given to these new challenges but a lot of scientific questions are pending. This paper is a brief review of the state of the art in the petroleum industry and the research needs are presented

1 NEW EXPLORATION CHALLENGES

Many papers have already dealt with the extension of the P, T and composition domain. *Elf* and *IFP* have developed together a high skill in this area, building new PVT equipments and adapting specific thermodynamic models. This efficient collaboration allows a significant reduction of the uncertainties in the development project of Elgin and Franklin fields where the pressure is around 1100 bar and the temperature close to 200 Celsius.

Now, the oil and gas companies are facing a new challenge with the deep offshore discoveries. Due to the low temperature of the sea bottom, the reservoir temperature could be very low under high pressure, in some extreme cases the trap could be sealed by hydrates. For such development projects the main concern is the risk of solid phase deposition, wax, asphaltene and hydrates directly from reservoir fluid and not only in the process facilities or in the transportation lines. In order to be able to deal with such fluid systems, we have an urgent need for data acquisition and modelling of the solid/liquid/gas equilibria under high pressure.

2 QUICK LOOK TO NEW OPPORTUNITIES

Compared with the normal fluid characterisation and modelling procedure, quick look to new opportunities implies some specific predictive tools. PVT correlations are widely used in that case but their application's range is limited and they often lead to inconsistent set of estimated data. To avoid these drawbacks, we decided to build a thermodynamic tool for the estimation of fluid properties from limited data input. The basic idea is: all the fluid properties can be easily derived from an Equation of State if the composition and the thermodynamic properties of components are known. So we just need to predict the composition of the fluid assuming a realistic set of thermodynamic properties for the components.

The Equation of State and the mixing rules are no longer used in a predictive way. At first, an initial guess for the fluid composition is made and the thermodynamic model is used to calculate the available properties of the reservoir fluid, typically the stock tank oil density and the gas oil ratio. Then the fluid composition is tuned until the calculated properties match the field data.

The number of experimental field data is generally much lower than the number of available tuning parameters, therefore we substitute in some constraints issued from a statistical analysis of the compositions of petroleum fluids from all over the world. Alterations of the fluid compositions due to migration or biodegradation are also taken into account in this approach.

The old PVT correlations provided the properties one by one, the new thermodynamic correlation allows the calculation of all the PVT properties which can be derived from an equation of state. The accuracy of the estimations denotes that the reservoir fluid compositions are not at random but it exists many regularities despite of the origin of the fluids is. The thermodynamic model ensures the consistency of all the estimated PVT properties and the thermo-gravitational model is used to extend the fluid composition to the whole reservoir.

One of the main drawback of this approach is the lack of information linked to the presence of aggressive compounds or trace elements which could lead to unexpected extra-costs in the development scheme. It is the same for the evaluation of the risk of wax and asphaltene deposits.

Ongoing research will certainly contribute to reduce the remaining uncertainties on the estimated fluid composition.

3 EXTENSION OF LOCAL INFORMATION TO THE WHOLE RESERVOIR

In the reservoirs, the fluid are not homogeneous and the information obtained from several samples must be extended to the whole reservoir. In order to assess the fluid composition everywhere in the reservoir, it is necessary to take into account the driving forces like the gravitation or the thermal gradient. Afterwards, at each point, the properties are calculated assuming local thermodynamic equilibrium.

Gravity forces are well-known and the accuracy of gravity segregation modelling is only dependant on the accuracy of the thermodynamic model in terms of absolute chemical potential. On the contrary, experimental data on thermodiffusion coefficients are very scarce due to the small magnitude of this phenomenon and to the thermal convection which could hide it. A lot of experiments have to be performed before we can predict with a reasonable accuracy of the compositional changes induced by a thermal gradient.

Once the distribution of composition and properties is established, the production profiles are estimated with reservoir and process simulators under given technical and economical constraints. Several scenarios are considered, and the corresponding uncertainties are evaluated for a more secure decision process.

4 CONSISTENT RESERVOIR AND PROCESS SIMULATIONS

The use of consistent models for reservoir and process simulation is very important among the objectives of reservoir fluid evaluation.

The advantages of using a consistent fluid model in the reservoir engineering and process integrated studies are obvious in the case of severe specifications on the processed products.

During the life of the field, the wellstream composition is changing and the processing facilities must be able to handle all the streams and to deliver the same product quality. Therefore an accurate estimation of the wellstream composition for the whole life of the field is requested. Unfortunately, in many field production schemes, the wellstream composition depends on the processing conditions. This is obvious in the case of gas injection but it can be true also in more simple cases where the composition of the stream depends on the current reservoir pressure which depends both on the production rate and on the well-head pressure required for the process.

The strong coupling between process and reservoir simulation leads to several numerical approaches of the process in reservoir simulation: equilibrium factors, split factors, pseudo-process or real time coupling of the two simulators.

For any selected software coupling method is, because of the huge number of grid blocks in a full field reservoir model, the number of components must be drastically reduced compared to the fluid description needed for the process calculations.

The consistency between models can be achieved by using appropriate lumping/delumping procedures.

In almost all the simulation performed today, lumping and delumping procedures are used but most of them are based on the initial detailed compositions of the lumped components.

These techniques can be improved and there is room for comprehensive studies of the fluid chain from the very first initial composition estimated to the last predicted production profile before development decision.

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