Total gas recovery maximisation

In the short term operation, the most important problem is related to the Total Gas Recovery Maximization. In order to withdraw as much natural gas from a reservoir as possible, one option is to use waterflooding. This leads to the problem of finding an optimal water injection rate with respect to different objectives, such as the maximal ultimate recovery, or the total revenues. Indeed there are several objective functions due to different aspects of the problem.

Modeling and algorithmic considerations:

Consider two wells drilled on the surface of the gas reservoir, one for gas recovery and one for water injection. Therefore, let r(t) denote the withdrawal rate of gas which is bounded by the maximum rate of gas extraction rm(t). Through the water injection, well water is injected into the reservoir at the nonnegative rate s(t). This model assumes a constant g which is the ratio of gas entrapped behind the injected water to the volume of water at any time. The model aims at maximizing the ultimate gas recovery and can be posed in a nonlinear form. Some researchers discuss several other objective functions. For example, the objective function to maximize the present worth value of the net revenues for internal rate of return.

The application of concepts from systems and control theory to oil and gas production is the unifying idea behind the current research theme Production Systems and Subsurface Characterisation and Flow. By means of modelling, monitoring and control, the Production Systems theme aims at stabilising and optimising production in order to achieve production targets, which are being expected from an operator through long term contracts.

Past. In the previous years, research and development was focused on three main areas:

1. The innovation of concepts for the hydrocarbons production process. This includes the application of smart wells, advanced, geophysical monitoring techniques, downhole treatment, the separation and conversion of substances and the injection of residuals (waste). Closed-loop 'measurement and control' concepts from system theory will play an important role;

2. The development of an integrated 'real-time' dynamic simulation, inversion and validation environment for reservoir, well and processing facilities. This environment will be used to test and evaluate newly developed technology from our groups and other sources. This environment is used as a learning environment and for work process analysis and optimisation;

3. Laboratory of innovation. The analysis and testing of methods, techniques and work processes to accelerate the process of innovation in the Energy and Production sector.

Present. Currently, the application of concepts from systems and control theory to oil and gas production is the unifying idea behind the research themes Production Systems and Subsurface Characterisation and Flow. By means of modelling, monitoring and control, the Production Systems theme aims at stabilising and optimising production in order to achieve production targets, which are being expected from an operator through long term contracts.

Future: Smart wells and smart fields

Smart well technology involves down-hole measurement and control of well bore and reservoir flow. Drilling and completion techniques have advanced significantly over the last years and allow for the drilling of complex multi-lateral and extended reach wells, and the installation of down-hole inflow control valves, measurement devices for flow, pressure and temperature, and processing facilities such as hydro-cyclones in the well bore.

Smart fields technology, also referred to as 'e-field' or 'digital oilfield' technology involves the use of reservoir and production system models in a closed-loop fashion. The measurements may originate from sensors in smart wells, but could also involve simple surface measurements from conventional wells, or originate from other sources such as time-lapse seismics.

Research in smart fields is now focused on the development of concepts and algorithms to improve hydrocarbon production though the use of systems and control theory. Future research will address the reservoir management aspects on time scales from months to many years, and in particular the development of techniques for closed-loop reservoir management. We are also developing methods to speed up the modelling and simulation part an order of magnitude. For this reason we combine fast and robust iterative methods for large linear systems with Model Order Reduction insights originating from Optimal Control research. This combination has already led to very good results. Various groups from the Delft University of Technology, Padua University and EPFL Lausanne collaborate in order to develop a new generation of simulators.

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