Dynamic Oil and Gas Production Systems Simulation and Optimization

Dimitrios I. Gerogiorgis and Efstratios N. Pistikopoulos
Centre for Process Systems Engineering, Imperial College London, South Kensington, London SW7 2AZ, U.K.

In an era of globalized business operations, large and small oil and gas producers alike strive to foster their profitability by improving the agility of exploration endeavours and the efficiency of crude oil production, storage and transport processes. They are faced with numerous acute challenges: ever-increasing international production, global competition, price volatility, policies dictating operational cost reductions – most of all, aggressive financial goals (revenue, cash flow and profitability) and strict environmental constraints. All the foregoing considerations should be incorporated and revised at will if the generality of production optimization algorithms is to be ensured. Their straightforward translation of these considerations to explicit objectives and constraints should yield optimal oilfield planning, design and operation policies, towards:
(a) Tactical Decision-Making (direct implementation of headquarters' business decisions)
(b) Operational Decision-Making (drilling, injection scheduling, surface capacity expansions).
(c) Execution Decision-Making (routine daily decisions of production operators)

Dynamic oil and gas production systems simulation and optimization is a research trend which has the clear potential to meet the foregoing challenges of the international oil and gas industry and thus drastically assist oil and gas producers achieve their growth vision and expectations. Previous work (Kosmidis, 2003) has already addressed successfully research challenges in this field, using appropriate correlations for two-phase flow of oil and gas in production wells and pipelines.

The complicated two-phase flow in a number of wells is the quintessential phenomenon during crude oil and gas transport. Despite intensive experimental study and extensive CFD simulations towards improved understanding of flow and phase distribution in wells, the knowledge extracted from abundant field data is not readily implementable in COTS optimization software. The integration of process systems modeling tools can effectively permit seamless employment of two-phase simulation in order to selectively enhance and assist gas production from gas-rich oil reserves and from relatively depleted oil wells. Multiphase Computational Fluid Dynamics (CFD) is an established computational technology that can elucidate the dynamic behavior of existing and potential production wells, enhance our understanding of flow and provide operation guidelines. Furthermore, coupling these full-scale multiphase CFD simulations with well performance and effluent composition history databases can provide reliable guidelines so as to ensure optimal management and maximization of natural gas production.

The present study faces and addresses the challenge of development of an integrated modeling framework treating the oil reservoirs, wells and surface facilities as a combined system. This can directly benefit from two-phase simulation of oil and gas flow, and therefore will allow optimisation of control valve settings and resource allocation in a production network. The components of this system are tightly interconnected (well operation, allocation of wells to well headers and manifolds, and gas lift allocation and control of unstable gas lift wells); therefore, explicit two-phase flow simulations using a state-of-the-art dynamic reservoir simulator (ECLIPSE, Schlumberger) are combined with the state-of-the-art equation-oriented process optimizer (gPROMS, PSE) to enable the integrated modeling and optimization of a relevant example problem.