SQP Method for Petroleum Surface Network Optimization

F. Delbos[1], **M. Gainville**[2], **and D. Sinoquet**[3]

Abstract: At IFP, optimization problems are encountered in many different applications, such as seismic tomography, characterization of reservoirs, engine model calibration, etc. Many of them are expressed as inverse problems with a nonlinear forward problem that is generally time consuming. Those problems have a number of variables varying between 10 and 10000. Moreover, the underlying optimization problems are often subject to inequality constraints. To solve these problems, we are developing a general optimization software package, called SQPAL, which should be flexible enough to fit the large variety of requirements of the applications being studied.

SQPAL is a Sequential Quadratic Programming algorithm developed to solve general nonlinear optimization problems having nonlinear equality and inequality constraints. A noteworthy feature of our approach is to solve the osculating quadratic problems by an augmented Lagrangian method, which has the potentiality to cope with large-scale problems since it does not require matrix factorizations. The performances of SQPAL on small and middle size NLP problems from the CUTEr benchmark are illustrated.

The industrial application we present is a surface network problem, which aims at maximizing the production of an oil or gas field while satisfying nonlinear network constraints. Two types of data are available: production data from well and network data. Production data are measures of pressure, oil/water/gas rates (the gas to oil ratio and the water cut ratio) and fluid composition at the wells. Network data include the topology and the characteristics of each elementary units of the network (pipelines, chokes, separators, ...). Parameters to be determined in this optimization problem are, for example, the bottom hole pressure of wells, the opening values of chokes or the gas lift rates. The software processes INDISS-TINA is the simulator used in this study. It simulates fluid flow in networks in steady and dynamic states. The steady state simulation is based on a sequential modular approach which consists in decomposing the problem into elementary units. These units compute their outputs from the information available on their inputs according to a predetermined order of calculation which takes into account the topology of the system. The potential of the SQPAL solver for this industrial application is illustrated on a synthetic problem that is representative of production systems for deep offshore fields (beyond 1000 meters).

[1,3] Department of Applied Mathematics
Institut Français du Pétrole (IFP)
1 & 5, Avenue de Bois-Prau, 92500 Rueil-Malmaison, France
frederic.delbos@ifp.fr, delphine.sinoquet@ifp.fr

[2] Department of Applied Mechanics
Institut Français du Pétrole (IFP)
1 & 5, Avenue de Bois-Prau, 92500 Rueil-Malmaison, France
martin.gainville@ifp.fr