

Global multi-objective optimization of a nonconvex MINLP problem and its application on polygeneration energy systems design

Pei Liu^a, Efstratios N. Pistikopoulos^{*a}, Zheng Li^b

^a*Centre for Process Systems Engineering (CPSE), Department of Chemical Engineering, Imperial College London, London, SW7 2AZ, UK*

^b*Department of Thermal Engineering, Tsinghua University, Beijing, China, 100084*

Session Description

Polygeneration, a multiple-input, multiple-output energy system that produces electricity and chemicals, is one potential energy conversion technology, which is both cost-effective and environmental friendly, hence providing an alternative towards meeting worldwide increasing energy demands and environmental constraints simultaneously. Detailed discussions of polygeneration energy systems can be found in [1, 2].

In this problem, we propose a multi-objective mixed-integer nonlinear programming (MINLP) formulation of a typical polygeneration process operating over a (long-term) horizon time. A typical polygeneration complex for the combined production of methanol and electricity has been selected to illustrate the methodology. Net present value (NPV) of the plant over its overall operating horizon is selected as the economic objective function, while a cradle-to-gate life cycle assessment based GHG emission indicator is considered as the environmental objective function. The polygeneration process is presented as a network of several interconnected functional blocks. Each block involves alternative technologies or types of equipment as candidates - the resulting superstructure captures all possible technical combinations (within the postulated set). For all blocks except the methanol synthesis one, mass and energy balances are established for all input and output streams. For the methanol synthesis block, the model involves chemical kinetics and phase equilibrium relationships to handle the different mole compositions of inlet syngas resulted from different technologies implemented in upstream blocks. The entire operating horizon time is discretized into a number of discrete time intervals, where all time-variant parameters are considered as piecewise constant functions (over these time intervals).

The proposed modelling strategy leads to a non-convex MINLP problem, upon which multi-objective optimization is performed. The multi-objective optimization procedure is parallelized using grid computing techniques, whilst each sub-problem (non-convex MINLP) is solved to global optimality using global solver BARON [3] in GAMS [4].

References

- [1] P. Liu, D. I. Gerogiorgis, E. N. Pistikopoulos, Modeling and optimization of polygeneration energy systems, *Catalysis Today* 127 (1-4) (2007) 347–359.
- [2] P. Liu, E. N. Pistikopoulos, Z. Li, A mixed-integer optimization approach for polygeneration energy systems design, *Computers & Chemical Engineering* 33 (3) (2009) 759–768.
- [3] N. V. Sahinidis, M. Tawarmalani, BARON 7.2.5: Global Optimization of Mixed-Integer Nonlinear Programs, User's manual, URL <http://www.andrew.cmu.edu/user/ns1b/baron/bibliography.html>, 2008.
- [4] R. E. Rosenthal, GAMS - A user's guide, GAMS Development Corporation, Washington, DC, U.S. .

*To whom all correspondence should be addressed.

Email address: e.pistikopoulos@imperial.ac.uk (Efstratios N. Pistikopoulos)