Designing Energy-Efficient Heat Recovery Networks using Mixed-Integer Nonlinear Optimisation

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Abstract

Many industrial processes involve heating and cooling liquids: a quarter of the EU 2012 energy consumption came from industry and industry uses 73% of this energy on heating and cooling. We discuss mixed-integer nonlinear optimisation and its applications to energy efficiency. Our particular emphasis is on algorithms and solution techniques enabling optimisation for large-scale industrial networks.

As a first application, optimising heat exchangers networks may increase efficiency in industrial plants. We develop deterministic global optimisation algorithms for a mixed-integer nonlinear optimisation model that simultaneously incorporates utility cost, equipment area, and hot/-cold stream matches. We automatically recognise and exploit special mathematical structures common in heat recovery. We also computationally demonstrate the impact on the global optimisation solver ANTIGONE and benchmark large-scale test cases against heuristic approaches.

As a second application, we discuss special structure in nonconvex quadratically-constrained optimisation problems, particularly through the lens of stream mixing and intermediate blending on process systems engineering networks. We take a parametric approach to uncovering topological structure and sparsity of the standard pooling problem in its p-formulation. We show that the sparse patterns of active topological structure are associated with a piecewise objective function. Finally, the presentation explains the conditions under which sparsity vanishes and where the combinatorial complexity emerges to cross over the P/NP boundary. We formally present the results obtained and their derivations for various specialised instances.

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