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Optimization of circuitry arrangements for heat exchangers using derivative-free optimization

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Abstract Optimization of the refrigerant circuitry can improve a heat exchanger's performance. Design engineers currently choose the refrigerant circuitry according to their experience and heat exchanger simulations. However, the design of an optimized refrigerant circuitry is difficult. The number of refrigerant circuitry candidates is enormous. Therefore, exhaustive search algorithms cannot be used and intelligent techniques must be developed to explore the solution space efficiently. In this paper, we formulate refrigerant circuitry design as a binary constrained optimization problem. We use CoilDesigner, a simulation and design tool of air to refrigerant heat exchangers, in order to simulate the performance of different refrigerant circuitry designs. We treat CoilDesigner as a black-box system since the exact relationship of the objective function with the decision variables is not explicit. Derivative-free optimization (DFO) algorithms are suitable for solving this black-box model since they do not require explicit functional representations of the objective function and the constraints. The aim of this paper is twofold. First, we compare four mixed-integer constrained DFO solvers and one box-bounded DFO solver and evaluate their ability to solve a difficult industrially relevant problem. Second, we demonstrate that the proposed formulation is suitable for optimizing the circuitry configuration of heat exchangers. We apply the DFO solvers to 17 heat exchanger design problems. Results show that TOMLAB/glcDirect and TOMLAB/glcSolve can find optimal or near-optimal refrigerant circuitry designs after a relatively small number of circuit simulations.

Keywords Heat exchanger design · Refrigerant circuitry · Optimization · Derivative-free algorithms

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