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OPTIMIZATION OF HEAT EXCHANGER FLOW PATHS USING A NOVEL INTEGER PERMUTATION BASED GENETIC ALGORITHM

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Abstract: Tube-fin heat exchangers (HXs) are widely used in air-conditioning and heat pump applications. The performance of these heat exchangers is strongly influenced by the refrigerant circuitry, i.e. the refrigerant flow path along the different tubes in the HX core. For a given number of tubes, the number of possible circuitries is exponentially large, and the traditional optimization algorithms cannot be used to optimize the circuitry for a given application. One of the challenges is that the thermodynamically feasible design space is a very small fraction of the total design space. Researchers have previously used Genetic Algorithms (GA) coupled with some variation of symbolic learning to solve this problem, but there is no guarantee that the resulting circuitry can be manufactured in a cost-effective manner. In this paper, we present an integer permutation based Genetic Algorithm (IPGA) for solving the circuitry optimization problem. A finite volume heat exchanger simulation tool is used to simulate the performance of different circuitries generated by the optimizer. A novel approach is developed to represent heat exchanger circuitry as a chromosome in the genetic algorithm. Six genetic operators are designed to operate on these chromosomes. A hybrid population initialization scheme is developed to speed up the efficiency of optimization by increasing feasibility of initial population. This population initialization scheme generates individuals from three sources, which are predefined circuitry generator, Latin Hypercube sampling and optimization of sub-problems with the goal of attaining short adjoining tubes (i.e. U-bends). Furthermore, the manufacturability aspect is handled using a constraint-dominated sorting in the fitness assignment stage of GA. An exhaustive search verification using a small heat exchanger indicates that IPGA is capable of finding optimal or near-optimal refrigerant circuitry designs with relatively low computational cost. The constraint handling technique can effectively improve the manufacturability of the optimal circuitries. The analyses of several test heat exchanger designs show that IPGA can obtain a 2.3-14.6% increase in heat exchange capacity compared with the manually designed counter-flow circuitry. A comparison with other circuitry optimization methods from the literature is also conducted and it is shown that the proposed IPGA approach can find designs which are better in terms of performance and manufacturability than those from the literature.