**MicroGroove Heat Exchangers Optimized with Multi-Objective Genetic Algorithms**

*MOGA Maximizes Advantages of Smaller-Diameter Copper Tubes*

**Montreal, Quebec (26 August 2019)** – MicroGroove technology has proven its worth in high-volume ACR products such as residential air-conditioners and heat pumps as well as light commercial refrigeration equipment. MicroGroove allows for the same cooling capacity to be realized using significantly less materials and less refrigerant charge.

To maximize these benefits, it is advantageous to run computer simulations, particularly those using multi-objective genetic algorithms, or MOGA. Typically, there are multiple constraints and objectives in the design of heat exchangers and the design space to be explored through simulations is very large.

MOGA systematically varies the parameters of a coil design and simulates the performance for each selected set of parameters. Genetic Algorithm (GA) is a type of evolutionary algorithm. A *population* of possible solutions is evaluated in each iteration. In a Multi-Objective (MO) algorithm, the decision is made from the resulting Pareto space *after* the search is complete. Heat exchanger designs that more closely meet the design objectives are selected from the resulting options.

MOGA was used in sampling the design space for several case studies of MicroGroove heat exchangers for a variety of applications. A paper presented at the 2019 International Congress of Refrigeration in Montreal describes five different optimization studies that were performed by Optimized Thermal Systems, Inc. (OTS) in collaboration with the International Copper Association and five different manufacturers [1]. In each case, copper tubes with diameters of 5 mm were specified and MOGA was used to optimize the configurations of heat-exchanger-geometry parameters.

Case studies included (1) heat-pump condensers to replace microchannel tubes with smaller diameter copper tubes; (2) a window air-conditioner condenser to improve system efficiency while reducing cost and refrigerant charge; (3) a refrigerator-freezer condenser to reduce hydrocarbon refrigerant charge; (4) the condenser of a packaged terminal AC system to minimize raw material costs and airside pressure drop while maintaining performance; and (5) an evaporator coil for a heat pump water heater to maximize capacity and minimize fan pumping power.

These diverse case studies demonstrate the advantages of smaller diameter copper tubes and the value of MOGA for design optimization. In many applications, MicroGroove heat exchangers can clearly outperform heat exchangers made from larger diameter copper tubes and performance can be comparable to microchannel heat exchangers. Results for specific applications are summarized as follows:

(1) *Heat-pump condenser*. The MOGA-optimized MicroGroove designs were similar to the baseline microchannel coil with regard to airside pressure drop and capacity.

(2) *Window AC condenser*. MOGA MicroGroove designs increased the efficiency of the heat exchanger while reducing material usage and refrigerant charge. MOGA designs improved the COP by as much as 15 percent and reduced material usage by more than 60 percent.

(3) *Refrigerator-freezer condenser*. Hydrocarbon refrigerant charge was dramatically reduced in the 5 mm designs. MOGA designs reduced the internal tube volume up to 41 percent along with a 57 percent reduction in overall coil volume compared to the baseline 6.25 mm copper tube designs [2].

(4) *PTAC condenser*. Raw material costs and airside pressure drop were reduced while maintaining performance. MOGA MicroGroove designs provided as much as 50 percent savings in raw material costs while keeping the pressure drop close to the baseline. The best design reduced the overall internal volume by 62 percent.

(5) *HPWH evaporator*. MOGA MicroGroove designs showed that capacity could be doubled by increasing fan power; and that 5 mm designs delivered more capacity than the 7.9 mm baseline heat exchanger for a given fan power.

**More about MOGA**

MOGA facilitates the optimization of heat exchanger performance using algorithms that mimic evolution in nature by carrying forward the traits of successful designs into future populations. MOGA has proven effective in the optimization of MicroGroove heat exchangers.

Evolutionary algorithms and specifically genetic algorithms are widely used in many fields. These algorithms are based on ideas about natural selection and natural genetics as originally developed in the 1960s and 1970s by John H. Holland at the University of Michigan. Interest in this multidisciplinary subject has only increased in recent years as computer simulations have improved in accuracy.

A description of the use of MOGA in the optimization of heat exchangers was presented at the Purdue Conferences in 2018 by Li, Ling and Aute from the University of Maryland [3]. MOGA allows for a large space of design solutions to be searched in a computationally efficient manner. The system performance can be simulated for each candidate solution and if the performance improves then it can be the basis for further mutations, i.e., alterations of variables. Optimized heat exchanger designs that would otherwise be missed can be identified through the combination of accurate simulations and MOGA.

The five manufacturer-driven case studies presented at the 2019 ICR illustrate the value of MOGA as applied to a new generation of tube-fin heat exchangers made from MicroGroove smaller diameter copper tubes.

**References**

1. Nigel Cotton, Hal Stillman, Dennis Nasuta, Yoram Shabtay, “Optimization of copper-tube coils for energy-efficiency and charge reduction in heat pumps, air conditioners and refrigerators,” *The 25th IIR International Conference of Refrigeration*, Montreal, 2019, Paper 854.

2. Nigel Cotton, Adam Rhoads, Anderson Bortoletto, Yoram Shabtay, “Optimization of MicroGroove Copper Tube Coil Designs for Flammable Refrigerants,” 17th International Refrigeration and Air Conditioning Conference at Purdue, July 9-12, 2018, Paper 2332.

<https://docs.lib.purdue.edu/iracc/2006>

3. Zhenning Li, Jiazhen Ling, Vikrant Chandramohan Aute, “Tube-Fin Heat Exchanger Circuitry Optimization Using Integer Permutation Based Genetic Algorithm,” 17th International Refrigeration and Air Conditioning Conference at Purdue, July 9-12, 2018, Paper 2598. <https://docs.lib.purdue.edu/iracc/2035/>

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