Air conditioner 'evolves' in novel study

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A new NIST tool combining principles of engineering with those of natural evolution yielded the design for a more energy-efficient roof-top air-conditioning unit. Credit: pedrosala - Fotolia.com

Played out on a computer over hundreds of generations, a survival-of-the-fittest programming method adapted by National Institute of Standards and Technology (NIST) researchers has spawned, of all things, the design for a more efficient rooftop air-conditioning system.

The evolutionary tack optimized the sequence of connections within the snaking arrangement of cooling tubes in the air conditioner's heat exchanger. The unit's U.S. manufacturer subsequently implemented the changes as a prototype for NIST. The computer-generated design yielded a 3 percent gain in overall performance, confirming the results of prior analysis by NIST researchers.

That amount of improvement could be enough for a manufacturer to achieve compliance with increasingly stringent energy efficiency standards. It also could translate into material savings—a reduction in the amount of costly copper tubing in a heat exchanger without sacrificing performance.

"What we're doing is identifying the best possible route through the heat exchanger for the refrigerant to follow so that it achieves the highest efficiency" explains NIST researcher David Yashar. "Given that the unit we studied has 144 tubes, the number of possible routes determined by a sequence of tube connections is astronomical, impossible for a human to explore using traditional methods."

The new NIST approach optimizes the connections among refrigerant-containing tubes so that maximum cooling occurs. This entails matching characteristics of incoming air, especially its temperature and velocity, with the temperature and other characteristics of the refrigerant.

"The objective is to optimally pair air and refrigerant at every location in the heat exchanger," Yashar explains. That kind of matchmaking can be extraordinarily difficult, he says, largely because the flow of air over the winding circuitry often is very uneven.

The proof-of-concept experiment* with the rooftop unit—like the ones used to cool office and apartment buildings—demonstrated the practical utility of the NIST approach of combining principles of engineering with those of natural evolution.

Yashar and colleague Sunil Lee first used a laser-based method to map how much and how fast air flows over the original refrigerant circuitry. These data were grist for a NIST computer model that simulates heat-exchanger performance. The team used this model with an algorithm that mimics the laws of evolution. The algorithm develops a population of tubing arrangements and the model evaluates the performance of each design in the population. The best potential tubing circuitries from one population served as the starting set for the next generation. After the number-crunching for several hundred generations of circuitry options was completed, a top choice emerged.

The ultimate solution was a circuitry design that increased the heat exchanger's potential cooling capacity by 8 percent and, when used to replace the existing design, boosted the entire system's energy efficiency by 3 percent.

In upcoming studies, the NIST researchers will test their optimization method on a window air-conditioning unit and a full-house, central air-conditioning system.

More information: Yashar, D. and Lee, S. Improving the Performance of a Roof Top Air-Conditioning Unit by Refrigerant Circuitry Optimization (NIST Technical Note 1806), July 2013. Downloadable from: www.nist.gov/manuscript-public … ch.cfm?pub_id=914090

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