PTAC Optimization Using a Multi-Objective Genetic Algorithm (MOGA); Findings from Studies on Heat Exchangers with Smaller Diameter Copper Tubes

Smaller-diameter copper tube-fin heat exchangers can now be designed using new empirical tube-side correlations and computational fluid dynamics (CFD)-based airside correlations implemented in coil modeling software such as CoilDesigner® (from CEEE, UMD, Maryland). Accurate simulations using such software allows designers to weigh the benefits of smaller-diameter tubes without having to build and test as many prototype heat exchangers.

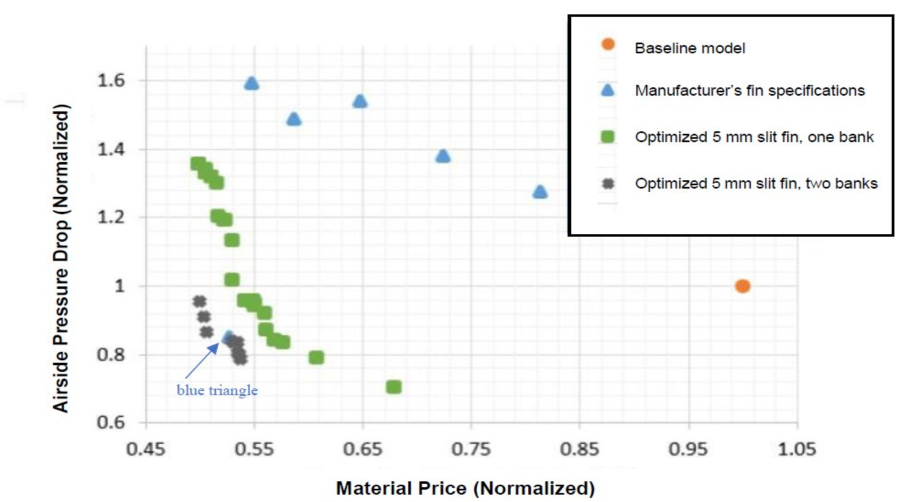
The case study below presents findings of a MOGA-based study for Packaged Terminal Air Conditioner (PTAC) systems, self-contained heating and air conditioning systems commonly found in hotels, motels, and apartment buildings.

The objective of the study was to identify an optimal drop-in replacement for the condenser of an existing PTAC product, while also seeking to minimize raw material costs and airside pressure drop while providing the same level of heat rejection. Geometric constraints in this study included the coil height, width, and depth. Figure 1 shows the optimization results – standard for MOGA simulations.

The blue triangles represent results obtained using MOGA to identify heat exchanger designs using a commercially available slit-fin pattern. One design in particular reduced raw material cost by 47 percent and decreased the airside pressure drop by more than 15 percent, while reducing the internal volume by 58 percent and maintaining acceptable refrigerant pressure drop as the baseline model (orange circle).

The green squares plot MOGA optimization study results using fin geometries, currently unavailable, but that are consistent with current manufacturing capabilities. These results yielded up to 50 percent savings in raw material costs and maintained pressure drops close to the baseline.

The greatest reduction in internal volume, 62 percent, was obtained using two tube banks in the airflow direction. However, one existing slit-fin design showed a similar reduction in cost and air pressure drop, indicated by the single blue triangle near the grey clusters.



The study accomplished the objective of identifying new condenser designs that have significant potential to reduce costs and maintain performance. This is a direct demonstration of how the incorporation of smaller diameter copper tubes in heat exchange design can result in a more efficient system that reduces energy consumption and operational costs.

The large reductions in airside pressure drop, as recorded in heat exchange systems with smaller diameter copper tubes, are favorable for noise reduction and energy efficiency. This translates to smaller diameter copper tubes as an optimal tool for developing energy-efficient systems at a low cost.

The study also indicates a currently manufacturable fin sheet provides excellent performance compared to other optimized designs. This demonstrates manufacturers can achieve high levels of savings using an available fin die.