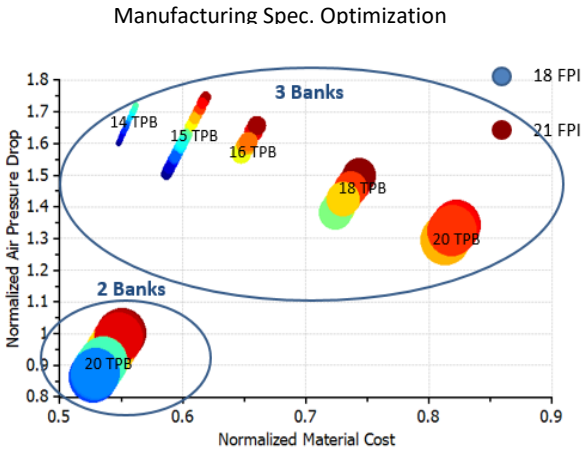
GE Appliances PTAC Condenser Optimization

Conducted by Optimized Thermal Systems, Inc.

Sponsored by the International Copper Association

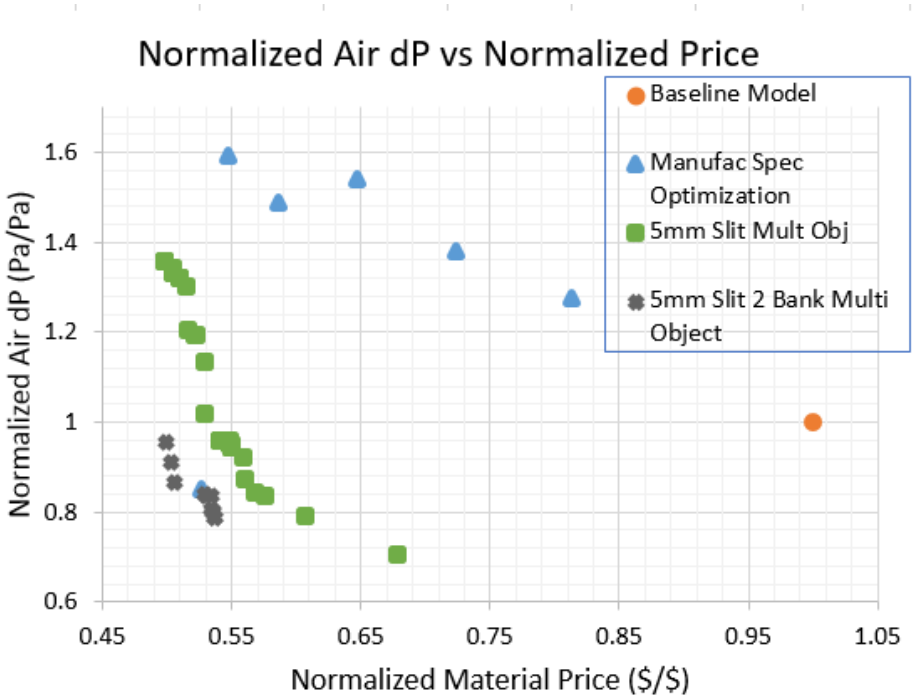
Optimized Thermal Systems, Inc. (OTS) recently conducted a design and optimization study for GE Appliances to identify small-diameter copper tube heat exchangers to replace the condenser of a packaged terminal air conditioner (PTAC) system. OTS used CoilDesigner®, a heat exchanger design and simulation software tool, to evaluate the performance of various designs and perform several optimization studies using a multi-objective genetic algorithm. The objectives of the optimization were to minimize raw material costs and airside pressure drop. In order to design drop-in replacements of the existing heat exchanger, geometric constraints were imposed, including the coil height, width, and depth and other limitations. The proposed designs were required to provide the same heat rejection without unduly increasing refrigerant pressure drop.

An initial optimization study was performed using a specific geometric configuration for an existing slit fin pattern. The analysis identified designs that had up to 47% savings in raw material costs over the baseline while also lowering the airside pressure drop by 15% and maintaining acceptable levels of refrigerant pressure drop. Additionally, the internal volume of the heat exchanger was reduced by approximately 58% for this specific design. The figure below illustrates that a number of different heat exchanger geometries can be constructed using this slit fin pattern. By optimizing the heat exchanger designs, it is possible to achieve the same performance with less tubes, thereby reducing material costs.



A secondary optimization study was conducted to explore new fin geometries that are not currently manufactured. The design space consisted of variable ranges consistent with current manufacturing capabilities. This optimization found designs that were similar to that of the previous study with similar costs. The additional degrees of freedom in the second studies allowed the optimizer to find designs

with up to a 50% reduction in raw material costs while keeping similar airside and refrigerant pressure drop close to that of the baseline. The best design within this second study demonstrated a reduction of approximately 62% in internal volume for the heat exchanger. The figure below shows the optimized heat exchanger designs from several studies. The lowest-cost designs were identified by fully optimizing the fin geometry and evaluating new fin designs (green diamonds). Comparably low-cost designs with reduced air-side pressure drop were identified and use only two tube banks in the airflow direction (dark blue dots). However, the one design using the existing fin shows a similar reduction in cost and air pressure drop (light blue triangles)



In summary, OTS identified several new condenser designs with significant potential to reduce costs while maintaining performance. The reductions in air-side pressure drop may be favorable for noise reduction and the material cost savings may make it possible to develop more energy-efficient systems in the future at a low cost. Furthermore, the study indicated that a currently-manufactured fin sheet provides excellent performance, which is comparable to other optimized designs. This finding means that GE Appliances can achieve a high level of cost savings using an available fin die without the need for retooling.