



## **EXECUTIVE SUMMARY**

### **FINAL REPORT ARTI-21CR/605-20020 AN ASSESSMENT OF THE STATE-OF-THE-ART AND POTENTIAL DESIGN IMPROVEMENTS FOR FLAT-TUBE HEAT EXCHANGERS IN AIR-CONDITIONING AND REFRIGERATION APPLICATIONS – PHASE I**

The objective of this project is to evaluate the air-side heat transfer and pressure-drop performance of serpentine-fin, flat-tube heat exchangers. This assessment is conducted for smooth, corrugated, and interrupted fins, over a wide range of geometric and operating parameters, spanning HVAC&R applications. The performance of serpentine-fin, flat-tube exchangers is compared to that of conventional round-tube designs, which are considered the technology baseline. The research now reported includes a literature review, a preliminary comparison of flat-tube to round-tube performance, a computational fluid dynamic study of flow through the heat exchangers, and complementary modeling to predict the performance of flat-tube designs over a wide range of conditions. Recommendations are provided for a new experimental study to provide performance data for dry, wet, and frosted-surface conditions. Specific flow visualization and naphthalene sublimation experiments are recommended to understand the flow and heat transfer interactions in the flat-tube geometry. These data could be used to evaluate condensate retention and frost-formation effects on flat-tube heat exchanger performance, and to compare this behavior to that of the conventional round-tube geometry. Furthermore, such data could be cast into the form of engineering correlations useful for further design and development work.

A critical review of literature has been completed, and it is presented in Chapter 1, topically organized by heat exchanger geometry and parametric effects. Appendices containing a complete reference list, a subset list of important papers, an annotated bibliography, and detailed technical comments on the papers are provided to augment the literature review\*. Discrepancies in the literature are resolved in this review, and gaps in our current understanding are identified. In Chapter 2, the literature database is used to identify the physical parameters important to thermal-hydraulic performance, to delineate their range, and to select the best correlations available for each geometry and operating condition. A study of flow and heat transfer using computational fluid dynamics (CFD) is presented in Chapter 3, to better understand fin geometry effects and identify promising designs. Along with the CFD results, the “best” correlations are used in a complementary analysis to make a preliminary evaluation of flat-tube heat exchanger performance. Clear advantages under dry, low-Reynolds-number conditions are found for the flat-tube design in comparison to round-tube exchangers, and promising—but limited—results under wet and frosted-surface conditions are described.

Almost no frosted-surface data are currently available in the open literature for the flat-tube geometry. The findings from Chapter 3 show clear promise for the flat-tube designs; however, the results also show that further study is needed to complete the wet and frosted-surface evaluations of flat-tube heat exchangers. Recommendations for

\* The review and appendices have been provided as searchable PDF files on a CD, in order to allow for fast, efficient searches of the literature database on author, keywords, phrases, year, publication venue, etc.

experimental research, including a test matrix, are put forward at the end of Chapter 3. Final conclusions and recommendations from this research are summarized in Chapter 4.

This work provides a careful assessment of the serpentine-fin, flat-tube geometry for HVAC&R applications. The geometrical and operating conditions where this design may be superior to conventional exchangers are established, as are the conditions under which it may be inferior. These findings will be highly valuable to design and development engineers as they work toward the next generation of highly compact, energy efficient HVAC&R systems.