CoilDesigner
A Refrigerant-to-Air Heat Exchanger Simulation and Design Tool with Integrated Multi-Objective Optimization Routines

CoilDesigner is a flexible, user-friendly software tool that was developed to assist in the design, simulation, and optimization of air-to-refrigerant heat exchangers used in heat pumping, air conditioning, and refrigeration systems, as well as applications like automotive radiators, and water coils for fuel cells. CoilDesigner was developed by students and faculty from the Center for Environmental Energy Engineering at the University of Maryland under the Integrated Systems and Optimization Consortium (ISOC). The development has taken place through numerous research projects supported by a diverse group of multinational stakeholders.

CoilDesigner is a highly customizable tool with extensive capabilities for simulating tube-fin, micro-channel, and wire-fin heat exchangers of different geometries. One of the greatest benefits of CoilDesigner is its flexibility to model virtually any tube circuitry, including both merges and splits. The user friendly interface allows a user to connect tubes on-screen via consecutive mouse clicks. The software also supports multiple fin types and fins with holes. The number of tube rows and columns that the software can model is limited only by available computer memory. CoilDesigner’s solver analyzes a heat exchanger in a tube-by-tube fashion, where each tube is subdivided into as many segments as the user desires. Furthermore, in any segment where a flow regime change takes place, additional refinement of that particular segment is automatically performed by the software to identify the transition point. CoilDesigner provides built-in options for a user to automatically generate common coil circuitry, or to save any particular geometry in a template file for later use.

When simulating the performance of a coil the user has the option to impose either a mass flow rate boundary condition, which tends to solve very quickly, or a pressure boundary condition, which requires more solution time but accounts for unequal refrigerant distribution in the various circuits. Additionally, the user has the option to account for 2-dimensional air side inlet flow distribution in three variables (velocity, temperature, and humidity) to simulate uneven loading that may be caused by a fan or other flow conditions.

The ISOC software team provides ongoing development, support, and technical assistance for CoilDesigner. The software is updated continually with the latest heat transfer, pressure drop, fin efficiency, and void fraction correlations available from the literature. Over 30 such correlations are
presently implemented, and CoilDesigner supports the ability for a user to define and employ custom in-house or proprietary correlations. The interface also incorporates an option to apply appropriate correction factors to the built-in correlations to provide a closer match between predicted results and experimental data. Within the CoilDesigner platform the user has the ability to perform parametric analyses on coil geometries and operating conditions by varying coil dimensions such as tube diameter and length, fin spacing, and by varying refrigerant or air inlet parameters. This feature gives the designer an ability to investigate coil performance and sensitivity to different environmental conditions and to different manufacturing options. CoilDesigner also incorporates built-in and user defined cost functions, which help to capture the economic impact of engineering decisions when designing a coil. Detailed results of parametric studies can be viewed and plotted within the program, and can be exported to a spreadsheet or optionally in formatted text.

One of the premier features of CoilDesigner is the integrated multi-objective optimization routines that have been built-in to the software. CoilDesigner has the ability to perform optimization on continuous variables such as tube length or fin spacing, or on discrete variables such as tube diameters, which are typically available in a limited number of sizes. Discrete optimization is implemented in CoilDesigner through the use of genetic algorithms. Figure 1 shows the results of an optimization study that was completed on a condenser. The objective of the study was to maximize heat load and minimize coil cost relative to a baseline coil. The results of a multi-objective genetic algorithm optimization lead to a set of optimum values known as Pareto Solutions, shown as red dots in Figure 1. The pink dot represents the baseline coil.

Throughout the development of CoilDesigner, extensive efforts have been taken to validate its prediction capabilities against experimental data. Figure 2 shows the results of a validation study for an indoor heat pump coil used in both heating and cooling modes in two different systems. All of the predicted data, with exception of only two points lies within ±5% of the experimental results. Similar studies have been completed, and continue to be performed, for different coils and operating conditions, all with comparable results.

CoilDesigner provides a well integrated, experimentally validated toolbox with a user-friendly interface for designing, simulating, and optimizing the performance of air-to-refrigerant heat exchangers for use in heat pump, air conditioning, and refrigeration systems, as well as applications like automotive radiators, and water coils for fuel cells.

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**Figure 1.** Results of a Condenser Optimization Study.

**Figure 2.** CoilDesigner Validation Study.