Integrated Systems Optimization Consortium

Reinhard Radermacher and Vikrant Aute

Center for Environmental Energy Engineering,
Department of Mechanical Engineering, University of Maryland, College Park, MD, USA
raderm@umd.edu

1. Introduction

The research at the Integrated Systems Optimization Consortium focuses on the development of validated component based models for the simulation and optimization of energy conversion systems.

2. Key Features

The research at ISOC culminates into verified component based simulation software which also serves as a means of technology transfer to research sponsors. Modeling tools currently under development are CoilDesigner, VapCyc, TransREF and TSIOP.

CoilDesigner is a user-friendly tool for the design and simulation of air cooled heat exchangers. The program simulates traditional tube-fin coils, microchannel heat exchangers, and wire-fin condensers with forced and natural convection. The component based development facilitates a very high level of customization. The user can assembly coils on-screen via consecutive mouse clicks. There is no limit on the size of the coil that can be modeled using CoilDesigner. The program can also account for multiple splits and merges of refrigerant flow in the same coil. The program offers several customization features such as (i) Ability to add user-defined heat transfer, pressure drop and void fraction correlations (ii) Ability to input 2-D air flow maldistribution on the coil face (iii) Account for distributors and the connecting tubes (iv) ability to use fan models that can be supplied in the form of a database, (v) ability to add user-defined fluid as refrigerant, etc. Several validations have been conducted across multiple product lines to build confidence in the tool. These validations have been published at several conferences. Overall 400,000 different coil simulations have been conducted in-house.

The ultimate purpose of having a simulation tool is to rapidly design and optimize new systems and component. CoilDesigner can be coupled with optimization algorithms to optimize coil designs. In a typical coil optimization, the problem is Multiobjective in nature i.e. the user wants to minimize the coil cost and at the same time maximize coil performance. For such Multiobjective optimization, CEEE-ISOC has developed Multiobjective genetic algorithms (MOGA). One of the salient features of MOGA is that it can simultaneously handle discrete and continuous variables. The results from a MOGA are obtained as a set of Pareto optimal designs. Pareto optimal points are designs in which one objective cannot be improved without causing certain amount degradation in the other objective value when moving along the Pareto curve. These Pareto optimal designs allow the user to make a trade-off between the different objectives. In the plots show, we observe that for the same (existing) cost, the optimizer finds systems that are better than 15% in terms of performance, for example.

VapCyc is a tool for the steady state simulation of vapor compression systems. The program uses a component-based approach that allows the end-users to develop and include their own component models in the program. The different component models include evaporators, condensers, compressors, expansion devices, fans, suction line heat exchangers, accumulators etc. The program has been extensively validated. VapCyc includes built-in Multiobjective genetic algorithms for single and Multiobjective optimization. The user can assemble systems through a simple point-and-click user interface.

TransREF is a tool for the transient simulation of vapor compression systems mainly geared towards refrigerators. The program is component based i.e. the end-users can include their own component models in the program. The program features several fixed configuration systems that the user can modify. It also includes very detailed cabinet models. The program allows the user to add multiple control algorithms in cascade thereby allowing the user to evaluate optimal control strategies for the refrigeration system. The program is currently being expanded to include residential and automotive air-conditioning systems.

Thermal Systems Integration & Optimization Platform (TSIOP). The long range goal at TSIOC is to develop a unified framework that allows the design and optimization of energy conversion systems in the most cost effective manner. TSIOP framework comprises several different components that stem from multiple disciplines such as heat transfer, fluid flow, mathematics, structures and manufacturing. The check marks indicate that the respective modules have been developed and are in use.

3. Conclusions

Simulation tools play a very important role in the design and optimization of new as well as existing thermal systems. The systematic search for better designs can lead to significantly improved designs that would not have been found otherwise.

4. References and Bibliography

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Author Biographies

Dr. Reinhard Radermacher, *Director CEEE, Professor of Mechanical Engineering,* is an internationally recognized expert in working fluids for energy conversion systems; in particular heat pumps, air-conditioners and refrigeration systems. His work has resulted in over 150 publications, including 3 books he co-authored, numerous invention records and 9 patents. He was a Visiting Scientist and NATO scholar at the National Institute of Standards and Technology before joining the University of Maryland. He currently serves as Editor for the ASHRAE HVAC&R Research Journal.

Mr. Vikrant Aute is a Faculty Research Assistant and serves as Director, Integrated Systems Optimization Consortium. Mr. Aute has six years of experience in software development for thermal systems and research interests include energy systems simulation and optimization with focus on application of multiobjective, multidisciplinary optimization algorithms to thermal systems design.