Final Frontiers in Vapor Compression Cycle Efficiency

A short course on potential performance improvements of vapor compression cycles

Sunday, July 10, 2016, 8:00 a.m. to 5:50 p.m.

STEWART CENTER
Purdue University
West Lafayette, Indiana

Organized by
U. S. National Committee of the IIR
Ray W. Herrick Laboratories

Short Course Description

The efficiency of vapor compression cycles used for refrigeration and comfort cooling/heating has steadily increased since the US Department of Energy initiated minimum efficiency requirements in the early 1980s. Some current offerings have SEER values that are more than double the initial DOE minimum SEER of 10.0. These efficiency improvements have been the result of better compressor designs, larger and more efficient heat exchangers, better expansion devices, and more efficient motor technology. While efficiencies have risen substantially, they are still just a fraction of the theoretical Carnot efficiency. So where do opportunities exist for additional increases in system efficiency?

The short course speakers will evaluate the various components of the vapor compression cycle to identify all areas that still offer economic opportunities for even higher system efficiencies. Case studies using optimization methods will show how to “invent” new heat exchanger shapes that go beyond tube-fin and micro-channel designs, as well as overall system optimization while considering system level performance metrics. In addition, an overview will be provided for other thermodynamic cycles that may hold promise to compete with, or even surpass, the traditional vapor compression cycle that is used in the majority of refrigeration or comfort cooling/heating applications.

Recognized experts with understandings of economic and practical manufacturing limitations will share their knowledge and real-world experiences in discussing how the next generation of refrigeration, air-conditioning, and heat pump systems will be designed.

*Electronic presentation files will be provided to all participants. Those attending the short course should bring a laptop computer to follow along and take notes.*
REFRIGERATION SHORT COURSE SCHEDULE - Sunday, July 10, 2016

7:30 am  Registration (continental breakfast provided)

8:00 am  **Course logistics, introduction to course topics**  
*William Murphy*

8:20 am  **Compressor Performance Opportunities**  
*M. Perevozchikov, Emerson Climate Technologies*  
Market requirements; loss analysis; technologies to improve compression; mechanical and motor efficiency; compressor architecture high side/low side

9:35 am  Coffee Break (refreshments provided)

9:50 am  **Heat Exchanger Opportunities**  
*B. Fox, Trane Commercial Systems*  
Air-side enhancements; refrigerant-side enhancements; microchannel, round tube/plate fin, and alternative geometries; tube diameter history and drivers; size/weight limitations; reliability; materials improvements; fan & system interactions

10:50 am  Coffee Break (refreshments provided)

11:00 am  **Heat Exchanger Opportunities (cont’d.)**

11:40 am  Box Lunch (provided)

12:20 pm  **Expansion Device Opportunities**  
*Vance Payne, National Institute of Standards and Technology*  
Brief history; thermostatic/electronic devices; energy recovery devices (ejectors); multiple stage expansion; MEMS/non-traditional expansion devices

1:20 pm  Break (refreshments provided)

1:30 pm  **Cycle Enhancement and Hybrid Cycle Opportunities**  
*Yunho Hwang, University of Maryland*  
Multiple stage compression/expansion; hybrid cycles; cold climate cycle options; separate sensible and latent cooling options

2:45 pm  Break (refreshments provided)

3:00 pm  **Component and System Optimization Opportunities**  
*Vikrant Aute, University of Maryland*  
Applications of systematic optimization to HVAC&R systems and components.  
- Overview of systematic optimization
- Case Study - 1: Heat exchangers, shape optimization and validation
- Case Study - 2: Simultaneous system and component optimization
- Lessons learned
4:20 pm  Break (refreshments provided)

4:30 pm  **Alternative Thermodynamic Cycle Opportunities**  
*Reinhard Radermacher, University of Maryland*  
Practical efficiency potentials for thermoelectric, chemical, acoustic, absorption, and other thermodynamic cycles

5:30 pm  **Questions for all speakers**

5:50 pm  Course evaluations, adjourn
Refrigeration Short Course Speaker Biographies

**Michael Perevozchikov,** PhD
Manager of Air-conditioning Research, Emerson Climate Technologies
Research Interests: Design and optimization of HVAC & Refrigeration components and systems
Numerous patents related to scroll compressor technologies
PhD Mechanical Engineering, St. Petersburg Polytechnic University (1997)

**William Fox,** PhD
Senior Heat Transfer Engineer, Trane Commercial Systems
Air to refrigerant heat exchanger design and system applications for applied and unitary commercial HVAC
PhD Energy Engineering, University of North Dakota (1997)

**William V. (Vance) Payne II,** PhD
Mechanical Engineer, National Institute of Standards and Technology (NIST)
Research Interests: HVAC components and systems; residential heat pump fault detection and diagnosis (FDD); two-phase flow and refrigerant expansion devices; experimental design and uncertainty analysis
PhD Mechanical Engineering, Texas A&M University (1998)

**Yunho Hwang,** PhD, FASME
Associate Director, Center for Environmental Energy Engineering
Research Professor of Mechanical Engineering, University of Maryland
Research Interests: Novel HVAC systems; refrigeration cycles; alternative cooling technologies; refrigerant mixtures; enhanced heat transfer
PhD Mechanical Engineering, University of Maryland (1997)

**Vikrant C. Aute,** PhD
Director of Modeling & Optimization Consortium
Associate Research Scientist, University of Maryland
Research Interests: Modeling and optimization of HVAC&R systems and components; next generation heat exchangers; adaptive design of experiments; approximation assisted and heuristic optimization; data visualization
PhD Mechanical Engineering, University of Maryland (2009)

**Reinhard Radermacher,** PhD
Minta Martin Professor, University of Maryland College Park
Director, Center for Environmental Energy Engineering (CEEEE)
Research Interests: Energy Conversion; Conventional and Alternative Heat-pumping; Air-conditioning and Refrigeration Systems; Novel Components and Cycles; Integrated System Optimization.
Work Experience: Mechanical Engineering Professor at University of Maryland for 30+ years; CEO of Optimized Thermal Systems, Inc.

**William E. Murphy,** PhD, PE, FASHRAE
Professor Emeritus of Mechanical Engineering
Research Interests: A/C system dynamics; ground source heat pump systems
PhD Mechanical Engineering, Purdue University (1980)