These four-hour long classes are given on the first day of the symposium, March 18, 2019. Designed to provide practical training on a wide variety of specific skills, short courses offer attendees an interactive learning environment.

Morning

Short Course 01

Statistical Analysis Methods for Dealing with Uncertainty in Thermal Testing

Ross Wilcoxon, PhD, Principal Mechanical Engineer, Mission Systems, Collins Aerospace

Course Description

Statistical analysis is a methodology for using probabilistic methods to address the uncertainty that is inherent to all data. This course will give an overview of fundamental statistical methods that are used to identify the useful signals within a data set that may otherwise be obscured by the noise of data uncertainty. The class will provide the attendees with a better understanding of the how and why various statistical approaches are used as well as give tutorials on how to use a number of statistical analysis methods on actual data.

About the Instructor

Ross Wilcoxon is a Principal Mechanical Engineer in the Rockwell Collins Advanced Technology Center. He conducts research and supports product development related to component reliability, electronics packaging and thermal management of avionics. Prior to joining Rockwell Collins in 1998, he was an assistant professor at South Dakota State University.

Short Course 02

Design and Optimization of Heat Sinks
Dr. Georgios Karamanis, Co-Founder and Senior Engineer, Transport Phenomena Technologies, LLC

Course Description

This course provides the audience with an understanding of heat sink design and optimization in the context of the thermal management of electronics. The course has two parts. The first part begins with an overview of common methods to manufacture heat sinks such as extrusion, die casting and forging, and discusses their advantages and disadvantages with respect to cost and fin geometry. Attention then shifts to the theory of spreading resistance and how it can be calculated in order to properly size the thicknesses of the bases of heat sinks. Next, the theory of the operation of heat pipes in tubular and flat (vapor chamber) configurations is presented along with their roles in smoothing out temperature gradients in the fins and bases of heat sinks.

In the second part of the course, single-phase conjugate heat transfer, where conduction in the heat sink is coupled to convection in the coolant, i.e., air or water, flowing through the heat sink is highlighted. We discuss why the constant heat transfer coefficient assumption tends to be an invalid one in real heat sinks by using specific examples. Then, the use of computational fluid dynamics (CFD) to compute conjugate Nusselt numbers is considered.

Next, we discuss how to embed pre-computed CFD results for conjugate Nusselt numbers and dimensionless flow resistances for heat sinks in flow network models (FNMs) of circuit packs such as blade servers.

Finally, a case study is presented where the fin height, length, spacing and thickness for 6 longitudinal-fin heat sinks cooling 6 microprocessors are simultaneously optimized by embedding the FNM representation of the circuit pack in a multi-variable optimization scheme.

About the Instructor

Dr. Karamanis is a Co-Founder and Senior Engineer at Transport Phenomena Technologies, LLC. He received his Ph.D. and M.S. in Mechanical Engineering from Tufts University. He has expertise in analytical, numerical and experimental technics relevant to convective transport. He is the PI in a NSF Phase I SBIR awarded to Transport Phenomena Technologies, LLC, to develop specialized thermal modeling software for Data/Telco centers.

Short Course 03

A Holistic Approach to Improve Mission Critical Facility Performance
Kourosh Nemati, Application Engineer, Future Facilities Ltd. 1

Course Description

In recent years, data center designers & operators have focused on energy consumption, particularly PUE, to decrease operating expenses (OPEX). Hybrid cooling solutions, containment, and air-side or water-side economizers are examples of solutions implemented in data centers to achieve lower PUE. While these solutions have a positive effect on OPEX, they can also increase Capital Expenses (CAPEX) significantly. Meanwhile, a major driver of increased OPEX and PUE continues to go largely unnoticed – the fact that IT equipment, cooling infrastructure and data halls are all designed and tested separately. Since all these processes operate independently, it is a tremendous challenge to integrate them into one tool. However, if this can be achieved, data center energy consumption can be improved while providing sufficient cooling for IT, even during critical failure.

This entry-to-intermediate-level short course will demonstrate a comprehensive “Chip to Facility” CFD modeling process, using the Future Facilities software platform. The course will cover the entire process of detailed server modeling and room-level modeling, including different types of cooling strategies and control systems both in design and operational planning. Additional topics will be presented, including: a standard for data center model calibration, model integration to DCIM/ITSM via API web services, and an overview of external (generator yard and rooftop) modeling.

About the Instructor

Kourosh Nemati is an application engineer at Future Facilities. He received his doctoral degree from the State University of New York at Binghamton. During his Ph.D., he has been involved in several data center thermal management projects, specialized in transport in data centers using both empirical and numerical approaches from server to room levels. He is a member of ASHRAE TC9.9, Green Grid and the NSF ES2 research project.

Short Course 04

Thermal Challenges in Automotive Electronics
Tobias Best, Managing Director, Alpha-Numerics GmbH

Course Description

Growing demands on electronic equipment in the automotive industry means a very precise consideration of thermal management is required. For several decades, there has been a trend that the performance increases, but the equipment gets smaller, leading to higher packing density. In addition to this challenge, which is common in other electronics industry segments, the automotive industry offers yet another hurdle. The installation space for the electronic equipment is usually not a simple boundary condition from a thermal point of view.

The thermal impact from solar radiation, noise-insulation (which acts as heat-insulation) and the effect of engine heat on electronics installed in the engine compartment all need to be considered. Without considering these effects in the design of the thermal management, the equipment might work as a prototype, but could completely fail in the field.

This short course will give an overview of the challenges an engineer will face when developing electronic equipment especially for the automotive industry. The course will concentrate on the physical area around thermal management and will show examples of the many challenges faced. The use of simulation to visualize the thermal behavior of the design and the creation of a digital twin for virtual prototyping will also be covered. The seminar will highlight some physical background concerning electronics cooling and will give ideas to help meet the latest requirements.

About the Instructor

With more than 20 years experiences using an industry specific CFD simulation tool and working as a consultant for the automotive industry, Tobias Best is currently owner and Managing Director of Alpha-Numerics GmbH in Germany.

Afternoon

Short Course 05

Introduction to the Design and Implementation of Indirect Liquid Cooling for Electronic Systems

Alfonso (Al) Ortega, Ph.D., Professor and Director, Laboratory for Advanced Thermal and Fluid Systems, Villanova University

Rahima Mohammed, Senior Principal Engineer, Intel Corporation

Course Description

The capacity of liquid cooling systems to manage heat dissipation from electronics far exceeds the capacity of air-cooled systems, a fact that has been known and pursued for decades. The preference for air cooling is readily justified because of ease of use and compatibility with electronics and their reliability.

Air-cooling performance is ultimately limited by volumetric constraints on the size of the extended surface heat sink attached to high power components, acoustic limits on the allowable volumetric flow rates, and availability of air-movers that can deliver flow at pressure heads sufficiently high to overcome the pressure drop in volumetrically dense finned structures.

Practically speaking, air cooling strategies cannot achieve heat sink resistances much below 0.1 C/W and component heat dissipations much greater than 100 W. Transitioning to liquids such as water or refrigerants as the primary heat transfer medium requires more exacting design and adaptation of infrastructure at system and component levels to accommodate delivery of liquid flow to high power devices.

This short course is intended for engineers who want to better understand strategic considerations in the selection of indirect liquid cooling solutions as compared to air-cooled solutions. The course will focus on the design and performance considerations for indirect (cold-plate based) liquid cooling solutions that use either single phase (liquid) or two-phase (boiling) convection as the primary strategy for heat removal. Topics to be covered include the following:

- Design drivers for liquid cooling transition in different platforms: Server, Desktop, Mobile
- System ramifications and trade-offs of solutions using liquid versus air cooling
- Design principles for single phase liquid-cooled cold plate design at conventional scales and emerging principles and data for micro-scale heat sink design
- Understanding the behavior of boilers/evaporators with mini or microscale features
- Design principles for liquid cooling systems and their implementation

About the Instructors

Dr. Al Ortega is the James R. Birle Professor of Energy Technology at Villanova University and the Director of the Laboratory for Advanced Thermal and Fluid Systems. For more than 30 years he has been a leading researcher in the area of electronics cooling fundamentals and applications and a teacher of the fundamentals of fluid flow and heat transfer and the design of thermal-fluid systems. He has published and lectured widely on air and liquid-cooling of electronics and experimental methods. He is a former General Chair of SEMITHERM and received its 2003 ”Thermi” Award. He is a Fellow of the ASME and the 2017 recipient of the IEEE ITHERM Achievement Award for career contributions to the field of electronics thermal management.

Rahima Mohammed is a Senior Principal Engineer and serves as the lead of the Customer Delight Office for strategic customers in Performance, Power and Competitive Analysis (P2CA) team of Intel Corporation. She has been with Intel over 20 years after graduate schooling from Yale. Before joining P2CA, she served as the Data Center customer solutions technologist and led data mining efforts on customer returned parts and as test and validation lead for server products in Manufacturing Validation Engineering (MVE).

Short Course 06

Design of Experiments (DOE) for Thermal Engineering

James Petroski, Principal Consultant, Design by Analysis Technical Consulting

Course Description

This course is intended to introduce people to the concept of Design of Experiments (DOE) and how it can be applied to engineering for effective design and experimentation. Beginning with a discussion of effective experimentation, the class will progress through different types of experimentation used today, the role of statistics in planning experiments and the product designs they influence, to an overview of various types of DOE's.
In depth presentation of certain DOE types will be given and the reason why the DOE type is chosen for a particular situation. The course will then show the process of setting up a "typical" DOE and follow with two examples, one from an analytical design using a DOE and a second of an experimental DOE of a system.

About the Instructor

James Petroski is the founder and Principal Consultant of Design by Analysis Technical Consulting. Mr. Petroski has been involved in thermal, shock and vibration management of electronics systems for DOD, NASA and commercial applications with over 35 years' experience in the field of electronics packaging and LED thermal management. He received his Bachelor's in Engineering Science and Mechanics from Georgia Tech and a MS degree in Engineering Mechanics from Cleveland State University. He has authored numerous papers related to LED and electronics packaging, has over thirty patents pertaining to solid-state lighting and electronics cooling, and is currently a member of the ASME K-16Subcommittee on Heat Transfer in Electronics.