SEMITHERM 33

Short Courses

Short Course 1

A History of Commercial CFD from Bernoulli to Spalding and Beyond, with a Focus on Electronics Cooling Simulation

Robin Bornoff, Mentor Graphics **John Parry, Mentor Graphics**

Since the early 1980s, commercially available CFD tools have evolved to play a central role in engineering design today. Limited by available compute power, CFD technologies were devised that offered usefully accurate results but required a high level of fluid dynamics and programming skills. The last 3 decades have seen a revolution in the industrial adoption of commercial CFD and widespread adoption for electronics cooling, due to compute power limits being relaxed, novel techniques developed, and usability enhanced. This short course tracks the rise of commercial CFD, in terms of technological capability, the impact of an ever-evolving hardware compute roadmap, integration into a wider design environment, and changing user persona. We will review the lessons learnt during this period, from compact modelling of complex and IP-restricted electronic parts, to pragmatic approaches that bring the power of simulation to bear on the initial architectural phase of product design. Illustrative examples will show how CFD has impacted different aspects of thermal design across packaging levels and stages in the development process.

Robin Bornoff attained a Mechanical Engineering Degree from Brunel University in 1992 followed by a PhD in 1995 for CFD research. He then joined Mentor Graphics Corporation, Mechanical Analysis Division (formerly Flomerics Ltd) as an application and support engineer, specializing in the application of CFD to electronics cooling and the design of the built environment. He is now Market Development Manager for the Physical Design of Electronics in the Mechanical Analysis Division.

John Parry attained a Chemical Engineering Degree from Leeds University in 1982, and a PhD in 1988. He joined Mentor Graphics Corporation's Mechanical Analysis Division in 1989 to manage its customer services operation, and later head its research activities. John has coordinated several collaborative research and knowledge transfer projects. With over 75 published technical articles, he is a member of JC15 and past chair of SEMI-THERM and has 4 patents pending.

Short Course 2

Fundamentals of liquid cooling: From fluid selection to phase change
Timothy Shedd, Ebullient Inc.

This short course will provide attendees with the tools they need to design liquid-cooled thermal management systems for virtually any challenge they may face. The course will begin with a review of the engineering fundamentals that form the basis for design and prediction of convective heat transfer on simple and complex surfaces. Next, we will apply these fundamentals to develop an objective, thermodynamic criterion for comparing arbitrary fluids on their merits. Proceeding to single-phase flows, we will compare the tradeoffs of different surface enhancements as well as employing more advanced techniques, including spray and jet impingement. We will look at practical examples of natural convection and how to estimate the performance of immersion cooling, which can be quite effective without active pumps. The final section of the course will cover an introduction to boiling and how to employ phase change in electronics cooling. Every topic in the course will be accompanied by practical examples and solutions methods that can be implemented, where possible, in common spreadsheet software.

Dr. Timothy Shedd had an early passion for technology and sustainable energy which led him to obtain a B.S. in Electrical Engineering from Purdue University in 1992. He began working with the Semiconductor Engineering Group at Digital Equipment Corporation (now part of Intel), and was a designer of the world's fastest commercial CPUs from 1988 through 1995. At DEC, Dr. Shedd first learned how computing power was limited by heat produced at the chips, and he helped to design one of the first commercial CPUs with active power control. Dr. Shedd completed M.S. and Ph.D. degrees in Mechanical Engineering from the University of Illinois at Urbana-Champaign. He became a professor of Mechanical Engineering at the University of Wisconsin-Madison in 2001, publishing over 45 peer-reviewed journal articles and many more conference and symposia publications. Dr. Shedd founded Ebullient in 2012. He is now full time with Ebullient as its CEO and CTO.

Short Course 3

Transient Thermal Analysis using Linear Superposition
Roger Stout, ON Semiconductor

The mathematical principle of linear superposition is a powerful and useful method of analyzing many thermal problems. This course will show how it may be applied to semiconductor and more general electronics packaging and system situations, in particular for time-varying power inputs to single and multiple heat-source applications. The "method of images" will be demonstrated for creating transient simulations of certain classes of non-symmetric thermal problems from simpler solutions. The use and significance and implications of Foster and Cauer thermal RC networks for transient analysis will be covered. Various features of Microsoft Excel as a tool for performing thermal analysis will be presented, including the use of Visual Basic. Multiple heat-source steady-state thermal problems, are, of course, a special case of transient analysis and will also be considered. Limitations of linear superposition will be discussed.

Roger Stout received his BSE in Mechanical Engineering at ASU in 1977, and as a Hughes Fellow earned his MSME at the California Institute of Technology in 1979. His full-time career then began at Motorola, which in 1999 launched its first spin-off, ON Semiconductor, where today Roger manages the Thermal and Mechanical Characterization Lab, which is part of the Packaging Technology Development organization within ON's Corporate Research and Development division in Phoenix, AZ. Roger has authored and coauthored more than 70 technical papers and presentations. He has been a peer reviewer for the IEEE TCPT Journal (and others). Roger holds six patents, and has been a registered Professional Engineer (Mechanical) in the state of Arizona since 1983.

Short Course 4

Spreadsheet Based Thermal Analysis Method
Ross Wilcoxon, Rockwell Collins

This course will show the attendees methods for using spreadsheets to do a variety of typical thermal analyses. It will begin with a brief overview of spreadsheet functions on cells and arrays as well as methods for more easily controlling the input and output of spreadsheet tools. This will be followed by discussions on the analysis of situations such as a thermal resistance network, flow within a chassis, uncertainty analysis of a thermal test stand and transient thermal behavior. Students will be provided with example spreadsheets that can be adapted for their own analysis needs.

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. He has contributed to the development of multiple systems for communication, processing, displays and radars for commercial and military avionics applications. His research areas have included rapid test methods for evaluating component reliability, heat pipes, liquid metal cooling, advanced composites and tin whisker mitigation. He is a past chair of the SEMI-THERM conference, has dozens of conference and journal publications and holds 29 US patents. Prior to joining Rockwell Collins in 1998, he was an assistant professor at South Dakota State University. He received B.S. and M.S. degrees in mechanical engineering from South Dakota State University and a Ph.D. in mechanical engineering from the University of Minnesota.

Short Course 5

Design of Experiments for Thermal Engineering
James Petroski, Design By Analysis

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.

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.

Short Course 6

Fundamentals of Power in the Data Center
Brian Zahnstecher, Power Rox

Power electronics in data center hardware can make or break the ability to enable an implementation for success or not. A common industry practice is to use simplified assumptions for loading and power conversion efficiency to provide approximate calculations of power utilization. Unfortunately, implementers find huge errors and variability between predicted and actual power consumption, which yield very costly (in CAPEX, OPEX, and time) headaches for many stakeholders. This is due to oversimplification of the highly convoluted and transient nature of power loading in the data center.

This entry- to intermediate-level Short Course will provide an in-depth investigation into what drives power requirements in data center equipment. The first part will focus on key attributes of data center hardware system power budgets. The second part will focus on rolling-up what was learned about power budgets at the system-level into the rack, aisle, and complete data center levels to provide the full picture of the data center power solution all the way from the load to the building inputs.

Brian Zahnstecher is a Sr. Member of the IEEE, Chair of the IEEE SF Bay Area Power Electronics Society (PELS), and the Principal of PowerRox, where he focuses on power design, integration, system applications, and OEM market penetration, and private seminars for power electronics. He previously held positions in power electronics with industry leaders Emerson Network Power, Cisco, and Hewlett-Packard, where he advised on best practices, oversaw product development, managed international teams, created/enhanced optimal workflows and test procedures, and designed and optimized voltage regulators. He holds Master of Engineering and Bachelor of Science degrees from Worcester Polytechnic Institute.

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