CALCE Inform Seminar Series

Application of Computational Fluids Dynamics (CFD) Analysis to the Thermal Design of Electronic Equipment

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Abstract

The thermal design of today’s electronic equipment relies significantly on the use of Computational Fluids Dynamics (CFD) software for the prediction of electronics thermal performance. In the early-to-intermediate product design phase, CFD analysis can be invaluable in selecting a cooling strategy and refining a thermal design by parametric analysis. In the final design phase, detailed analysis of product thermal performance is performed to provide boundary conditions for electrical performance analysis and reliability prediction. In this regard, however, the lack of methods to accurately predict electronics operational temperature, in terms of either absolute temperature, or spatial or temporal temperature gradients, is considered to hamper progress in reliability prediction.

Typically, the turbulent flow modeling capabilities of CFD software dedicated to the thermal analysis of electronics have been confined to zero-equation mixing length or standard two-equation high-Reynolds number $k$-$\varepsilon$ eddy viscosity turbulence models. These models meet the criteria of robustness, in terms of promoting stable convergence, and to some extent, universality, which make them popular for practical engineering calculations. They are by far the most widely-used and validated, and are considered as computationally viable in a design environment. Unfortunately, this approach is not entirely satisfactory for modeling the thermal and kinematic complexity of thermofluid problems in forced air-cooled electronic systems.

To optimize the potential of CFD analysis, many factors need to be taken into consideration which impact on predictive accuracy, namely: computational constraints, uncertainties in physical boundary conditions, numerical modeling simplifications, and inherent limitations in the code numerics and turbulence modeling. In this context, depending solely on CFD predictions without supporting experimentation still remains an unreliable design strategy, and an efficient approach therefore requires a balanced combination of both experimental and numerical efforts. This presentation provides guidance on optimizing the application of CFD analysis to electronic system thermal design in terms of modeling strategy and flow modeling approach, with no bias towards a particular CFD code.

About the presenter: Dr. Peter Rodgers is an Assistant Research Professor at the University of Maryland, College Park, where he supports the thermofluid research of the CALCE Electronic Products and Systems Center. Formerly, he was with the Nokia Research Center, Finland, and Electronics Thermal Management Ltd., Ireland, where he consulted on a wide range of aspects in electronics cooling. His current research interests cover both conventional and advanced cooling technologies for electronic equipment. Dr. Rodgers has authored or co-authored approximately 50 conference and journal publications on a broad range of topics in this area and holds a Ph.D. degree in mechanical engineering from the University of Limerick, Ireland. He has been an invited lecturer, keynote speaker, panelist and session chair at international electronics thermal management conferences. Dr. Rodgers received the 1999 Harvey Rosten Memorial Award for his publications on the application of computational fluid dynamics analysis to electronics thermal design. He is a member of the EuroSimE, SEMI-THERM and THERMINIC conference program committees, and is program co-chair for EuroSimE 2006.