UTSI professor, former student publish heat management paper

A more efficient way of simulating the cooling of transistor-containing electronic packages such as computers and communications equipment is advanced in a recently published technical paper written by a University of Tennessee Space Institute professor and one of his former undergraduate students.

The paper was authored by Dr. Joe Majdalani, now UTSI's Jack D. Whitfield Professor of High Speed Airflows, and Kyle A. Brucker, now at the University of California at San Diego. The work was done while both were at Marquette University.

At Marquette, supported by Cisco and Motorola, Majdalani says, "We engaged in helping companies model heat sinks."

Heat transfer in electronic packages is becoming a key research area, the professor said, for two reasons. First, transistors generate a certain amount of heat and, with more and more transistors being jammed into smaller spaces, the effect of heat buildup can become significant. Secondly, transistor efficiency decreases as temperature increases. Depending on the standard used, the maximum operating temperature for transistorized equipment is 130 to 160 degrees Fahrenheit.

The heat can be dissipated by one of two methods. For simpler applications, passive metal structures called "heat sinks" absorb the heat and then dissipate it through an array of fins. As the number of heat sources increase, fans are added to speed heat removal.

The authors explore the porous block model based on replacing a "heat sink" with a volume of air — a theoretical technique that helps to simplify the simulation process, according to Majdalani.

"Our proposal – in which the volume of fluid replaces the actual heat sink – helps to model heat sinks in a way that greatly simplifies the procedure," he added. "For instance, our approach reduces CPU (Central Processing Unit) usage by a factor of 10 to 50."

In practical terms, it means reducing computer time needed to solve the complex calculations from as much as a week to hours.

The explicit solutions that provided through their approach are not limited to simple rectangular shapes used in former studies, Majdalani professor explained. "Rather, we extend the analysis to cover most fundamental body shapes and flow configurations under both free and forced convection modes."

Analytical methods offered in the paper "allowed us to solve 38 free and 24 forced convection equations," the professor said.

Majdalani thinks the findings listed in the paper "increase our repertoire of engineering approximations, both in industry and academe, especially those devoted to heat transfer processes."

The International Journal of Heat and Mass Transfer immediately accepted the paper — without the usual lengthy judging process —

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and published it earlier this year. Dr. W.J. Minkowycz, professor of mechanical engineering and editor of the journal, praised the paper. In a letter to Majdalani, the editor wrote: "I have reviewed the paper carefully and find it to be of good quality. Indeed the quality standard of the paper merits its acceptance for publication without further review."

Citing "a growing interest" in thermal management of electronic packages, Majdalani said the Accreditation Board for Engineering and Technology (ABET) requires a thermal design project from all undergraduate institutions. A text publisher has recently moved the chapter on this subject from Chapter 14 to the Chapter 4, so that students are exposed to the topic early, Majdalani said.

This enables students to apply these tools to their thermal design projects. These include the simple solutions published by Brucker and Majdalani.

In the recently published paper, Majdalani says, "We show that analytical technology can solve very complicated equations. We show how to test the strength and breadth of perturbation methods (one of his graduate courses at UTSI) by tackling a large number of complex equations."

"Our paper illustrates a successful endeavor of working with undergraduates," said Dr. Majdalani.

"My experience working with undergraduates has been an excellent one. The success of this particular endeavor is one such example. I have learned that an undergraduate student with the proper attitude toward research can outperform a supercilious graduate who lacks maturity, accountability, or who displays emotional instability.

"In order for a graduate or undergraduate student to be successful, he or she must have a good attitude. I tell students, 'If you have a good attitude toward research, you can get wherever you want to be.' Kyle is a good example. He received the prestigious National Defense Science and Engineering Graduate Fellowship."