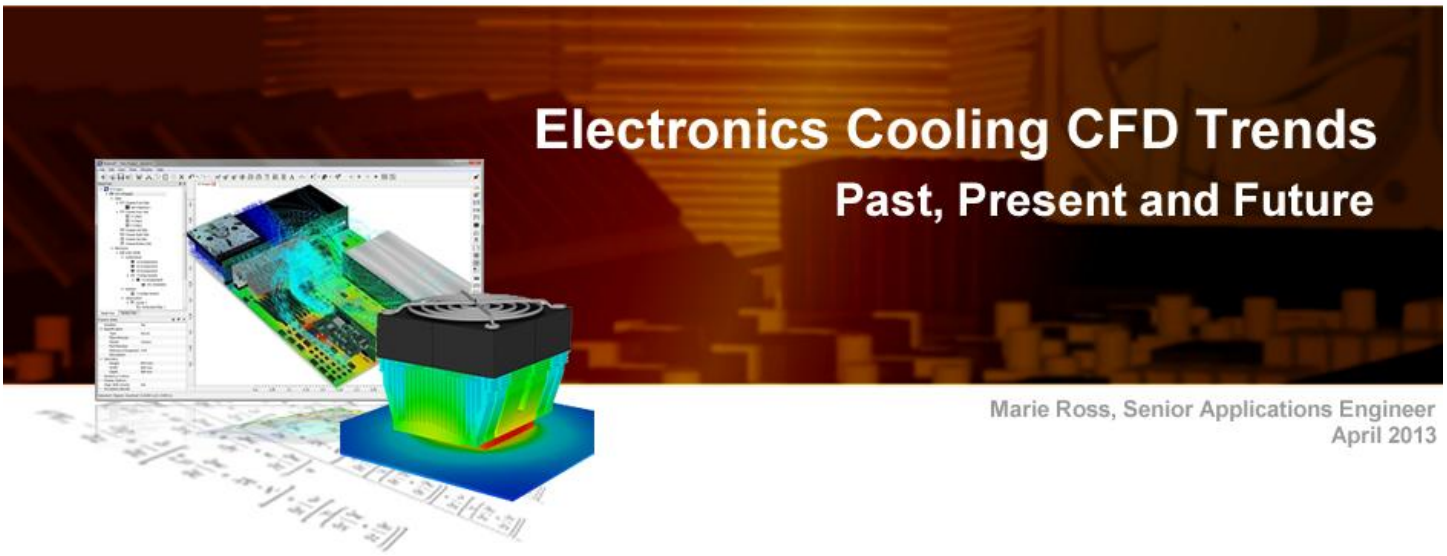

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Today's thermal engineer relies heavily on Computational Fluid Dynamics (CFD). This is a term given to the use of numerical methods to solve some form of the Navier-Stokes equations, or conservation of momentum. Software packages available on the market take these equations, couple them to those representing the conservation of mass and energy, and provide thermal engineers with a tool to address several design challenges.

In the beginning

Though the origins of CFD date back to the 1930s in the field of aerodynamics,[i] it was not until 1989 that CFD was properly introduced to the electronics industry by Harvey Rosten and Dr. David Tatchell[ii]. They pioneered the move away from general purpose CFD software which could simulate any fluid flow situation into application specific CFD software designed to efficiently solve a single class of problem. This revolutionized electronics cooling by drastically reducing the amount of time necessary to develop sound thermal designs. Instead of iterating between painstaking hand calculations, prototype building, testing, and redesign, engineers could simulate a digital prototype. It was now possible to narrow in on a solution before anything is built or tested, which results in substantial savings in both cost and time. An added bonus is the visualization of flow, which is difficult without sophisticated (and expensive) laboratory equipment. Rules of thumb were discarded, and thermal design margins were drastically reduced.

In 1989, a workstation running Unix was the monochrome platform of choice. Thermal engineers were highly specialized as one needed a solid understanding of both fluid dynamics and heat transfer to use the newly available CFD tool for the industry. The learning curve of which was significant.

It could take days to build the geometry in green and black wireframe splendor. Every cuboidal object (rectangular blocks and triangular prisms were the only choices) referenced an absolute coordinate system. Modeling errors could cost additional days to troubleshoot, so each cuboid was listed carefully in a notepad. One heatsink could be represented on a full page worth of cuboids.

Grid was based on keypoints making it essential that users be thoroughly aware of the underlying physics. Tack on another couple days to grid. A 20,000 grid cell problem would take a week of number crunching before any results could be analyzed. Engineers would take a deep breath and cross their fingers as they hit "Run." They were understandably anxious that models would diverge as this was a regular occurrence. Add on a few more weeks days for troubling shooting the grid and modeling assumptions.

"no major advancements have been made in the past 10 years or so"

Fortunately incremental improvements to the software, due partly to competition caused by new entrants to the market, drastically improved the daily life of a thermal electronics engineer. Enhancements to the graphical interface were made, rudimentary MCAD and ECAD import capabilities were introduced, and computational times shrank somewhat, but gridding and geometry building stayed essentially the same (though more shapes than blocks became available). And though these improvements significantly improved the initial CFD tools, no major advancements have been made in the past 10 years or so.

The incremental nature of software development can be prohibitive. Implementing the latest in computing technology and numerical methods is difficult when all development efforts have been built upon obsolete ones. It often requires a complete redesign, and in a competitive market that is not always the easiest choice. So even though drastic improvements in these fields have been realized, our industry's simulation software was not able to leverage them: Until now.

Learning from the past

By starting from scratch, software such as 6SigmaET has been able to drastically change the electronics thermal simulation landscape. The software has become intelligent. Instead of relying on the engineer to correctly form collections of generic cuboids into the items to be modeled and get the gridding right, 6SigmaET has specific items for specific functions. For example, it knows that a heatsink is a finned, conducting solid that requires airflow for adequate cooling. It knows that fans are controlled by sensors, and it knows that PCBs come with layers, traces and percent copper regardless of the units used.

"the software knows exactly what each object is and how it should behave"

It is now possible to seamlessly import MCAD and ECAD data into the solution domain while retaining all the relevant details. Gridding is done automatically and intelligently rather than just by keypoint. It is an intelligently generated grid reflecting decades of industry experience to properly capture the physics and the geometry. It is also optimized for both your model and the computing capacity of your computer.

A fast, distributed memory, parallel processing algorithm is able to take advantage of low-cost multicore and multi-processor computer systems to reduce compute times. Models that have in excess of 100,000,000 grid cells are nothing more than an overnight run (yes 100,000,000 is not a typo). Parametric analysis can be done on large, rather than simplified, models.

Modeling scales have been mastered. Today engineers can model the internal details of a component and analyze it in directly in a rack; a concept not even in the minds of thermal experts 10 years ago. Today we understand that it is the power of the component that costs millions of dollars to cool in the data center, and these costs are now the focus of attention of several large companies such as Facebook[iii], Intel[iv] and Hewlett Packard[v].

Recent software improvements are a major leap from the early days of simulation, and more advancements are on the way. Computing capacity continues to rise. Numerical algorithms are constantly being improved upon. The market is driving package size down while increasing functionality[vi]. Cloud computing, multimedia, and connectivity are growing in demand. Experts agree that the electronics cooling world is not getting any simpler, nor will it in the foreseeable future.

Nobody has a crystal ball (or at least one that works), but if you analyze the data it is evident that chip to chiller designs will eventually become commonplace. Cloud computing will enable on-demand cluster solvers. MCAD and ECAD data will eventually be fully integrated, and models will be built and monitored on a hand-held device. Numerical simplification will be as outdated as the monochrome screen that once seemed like such a futuristic advancement. A fully unstructured grid will accurately, efficiently and reliably converge every solution. It is even possible that you will, in Star Trek fashion, press a couple buttons on a console and verbally tell the computer what to do. But we are not there yet.

"a thermal engineer need no longer be a specialist"

The development of current technology when looked at from the perspective of 1989 is just as revolutionary as the instillation of CFD in electronics cooling. The time necessary to perform thermal analysis has been drastically reduced; in most cases by at least half. But the true revolution is in combining these new time savings with the fact that a thermal engineer need no longer be a specialist. By leveraging MCAD and ECAD data and using intelligent software, most issues can be analyzed effectively by a generalist. It does not mean that thermal engineers are no longer necessary, or that anybody can do thermal design. It is a function that still requires the knowledge, training and expertise of the engineering mind.

The engineer must still understand both the design purpose and cycle. The process of bringing products to market has not changed. Ideas are conceptualized, calculations are made, hardware is designed, simulated, prototyped, and tested. Engineers, and their judgment, are still necessary throughout. In fact, it is streamlining the design process that is necessary in future software development; aiding the engineer, not replacing him or her.

Thermal tools that develop niches in areas that do not look at the design cycle and the role engineers play in that process will not prevail in the market place. MCAD, for example, is usually done after initial design models have been run. It will never make sense to create detailed MCAD geometry before some basic thermal, mechanical and electric understanding is established.

Redefining the future

In 1989 an electronics thermal engineer could decide to simulate or not to simulate. That was their choice. Today the decision is different. Simulation is no longer an option, it is an engineering must. Today an engineer must ask themselves if they want to continue modeling as they have for the past 10 years or so, or if they want to move forward with the latest in thermal simulation and design integration. Tomorrow the question will change again. It will be interesting to see where technology leads us.

Learn more!

Advancements in Thermal Management 2013, June 6-7, Denver, Colorado.

If you would like to learn more on this topic, Marie will be presenting at the upcoming conference Friday June 7th at 11.15 am.

More information can be found at **www.thermalnews.com/conferences/**

[i] Milne-Thomon, L.M (1973). *Theoretical Aerodynamics*. Dover Publications. ISBN 0-486-61980-X.
[ii] www.rostenaward.org/harvey.htm
[iii] http://www.opencompute.org/
[iv] http://blogs.wsj.com/digits/2013/04/09/intel-moves-to-play-bigger-role-in-server-design/
[v] http://news.cnet.com/8301-1001_3-57578441-92/hps-new-project-moonshot-runs-on-intels-atom-for-now/
[vi] SemiTherm keynote address