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Interview –

Klaus Olesen
Danfoss Drives

Siemens PLM Software

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Thermal Design Specialist,
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Q. Tell us about Danfoss, and the Drives Division and what you do?

A. Danfoss is headquartered in Denmark and is a $5.5Bn company. I work in the Danfoss Silicon Power GmbH, in Flensburg, Germany, a part of the Danfoss Drives division. In late 2014, Danfoss Power Electronics acquired Vacon a Finnish motor drives company. Now Danfoss is the second biggest low-voltage motor drives manufacturer in the world. I am a thermal design specialist, responsible for developing new cooling technologies for our power electronic components and systems. I cover thermal, thermo-mechanical and fluid dynamics simulation tools (FEM, CFD), power electronics reliability and, lifetime assessment, from concept development to feasibility studies. Danfoss Silicon Power aims to be the best choice of power module supplier in the world with our off-the-shelf and customized solutions.

Q. You have worked for Danfoss for 25 years, what have been the major changes and trends you have experienced?

A. When I started in 1990, Danfoss was vertically integrated with many factories for supporting processes like chemical treatment, plastic molding etc. This has changed dramatically in the last 10 years as we have become leaner and have focused on our core capabilities while outsourcing supporting processes. In Flensburg, we focus on getting the best thermal designs for our power modules and tailor solutions to customer applications. We find that the market expects a cost reduction each year for control electronics and computers. While chip manufacturers need to have smaller chips, each generation with more current going through them (in a power law relationship). We are constantly challenged to deal with more heat, to manage in a shrinking space! In terms of applications for IGBTs, modern wind turbines are being designed for a lifetime of 15-20 years with the turbines expected to run 24 hours a day, 365 days a year when the wind allows. This corresponds to 150-180,000 hours of service which is 10-20 times the lifetime expectancy for typical automotive IGBT applications and 3-5 times the expectancy for other industrial applications. To secure sufficient reliability over the expected life of any such critical system calls for an in-depth understanding of the relevant failure mechanisms and mission profiles of the specific application.

Q. You invented the Danfoss ShowerPower® – the leading IGBT Liquid Cooling equipment for Power Modules. How has IGBT liquid cooling evolved over the last 10 years and what's next?

A. With greater and greater quantities of heat needing to be removed from IGBTs we recognized some time back that an effective form of liquid cooling was necessary. The ShowerPower invention was our patented response. We used CFD to design this complicated heat exchanger unit that was introduced to the market in 2008. We verified the CFD results against university experimental test data. We custom design and manufacture ShowerPower that attach to IGBT modules to maintain a constant surface temperature for optimal performance. We guarantee thermal and structural reliability of our solutions for long warranty periods without failures of the cooling circuits.

Q. How has your CFD design process evolved in the last 10 years?

A. For a typical customer application we may need to do 50 or more CFD simulations to check for good fluid flow and heat transfer in the ShowerPower. Ideally we want to compress our design cycles further each year, whilst dealing with increasingly complex geometries. We chose Simcenter FLOEFD™ as our CFD design tool because we didn't want to be CAD geometry and meshing jockeys. We wanted a tool that was user friendly, embedded in PTC Creo, our CAD tool, and accurate. I like Simcenter FLOEFD compared to other more complicated CFD tools because I can dip in and out of it all year with minimal effort to pick it up again. It's also robust and easy to mesh our complex geometries inside Creo. Our ShowerPower product is the best compromise between manufactured cost and homogeneous thermal performance with our use of aluminum heatsinks. We were the first to do effective liquid cooling and we intend to maintain our technical advantage.

Q. What do you see as future megatrends and challenges in your area of Power Electronics?

A. We are seeing bigger and bigger cities emerging all over the world with larger and larger electrical infrastructures that produce HVAC and power conversion challenges. Even the explosion of elevator and lift technology in tall city skyscrapers puts a challenge on next generation motor drives. Power densities are increasing each year. In the automotive sector with the increase in electrification of vehicles we are seeing demands for power electronics to be embedded in other components like gear boxes. This impacts their performance because of the aggressive environments they need to operate in and reliability is therefore key. I can also foresee whole new geometrical shapes and materials emerging from the 3D printing industry that we will have to deal with and even nanotechnology surface coatings for enhanced heat transfer will become a challenge for us over time.

Q. Where do you see CFD going in the Power Electronics arena in future?

A. In terms of computer-aided engineering (CAE) tools generally, I see a trend towards CFD and FEM structural analysis tools merging and offering true concurrent "multiphysics" solutions. Because electrical power losses lead to temperature effects (CFD) impacting structural deformations and crack formation (stress analysis) which in turn impact power thermal and structural changes over the component's lifetime – they're all interlinked. I also foresee the need for more design of experiments in CAE modeling of power electronics - to yield a precise die position in a module or to simulate a particular gate drive switching strategy. We will always need more and more simulations as early as possible in the design cycle. I think engineers in future will therefore need to be multi-talented, and in terms of CFD in particular, there will be an increasing need for early rough simulations to yield data to make faster and faster design judgements.

Q. The other part of your job is Power Electronics Reliability – how do you see that relative to your thermal expertise?

A. Yes, I cover lifetime assessment of IGBTs and this is becoming increasingly important as they run hotter and hotter in warmer ambient conditions where reliability is mission critical. We do "Physics of Failure" using a combination of statistical analysis, simulation tools and physical testing. We work closely with local universities at Aalborg and Fraunhofer to develop better techniques. The cycling and drive cycling our products experience obviously has a profound effect on their reliability. A big challenge we face is the change in physical properties of our materials over time during normal operation, due to the power loads they have to sustain and impairments in thermal performance.

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