HPC-ENABLED SIMULATION AIDS IN THE DESIGN OF CUSTOMIZED HIGH-POWER ELECTRICAL DEVICES

COMSOL Multiphysics and its HPC capabilities get the best designs to customers more quickly than ever before.

By **DEXTER JOHNSON**

BLOCK TRANSFORMATOREN-ELEKTRONIK is a leading manufacturer in the field of coiled products that are used in a wide variety of industries, especially for electronics applications.

BLOCK engineers design custom transformers, power supplies, EMC filters, and reactors (see Figure 1), which usually have to meet precise specifications concerning working frequencies, product sizes and weights, electrical power losses, electrical insulation, as well as varying environmental conditions, including dirt, temperature changes, or moisture. Additionally, such equipment must often have product lifetimes of 30 years.

"Depending on the customer's application, there are restrictions to the materials that may be used," said Marek Siatkowski, who is responsible for all of BLOCK's simulation activities. "For example, in railway applications, the materials must meet strict requirements like flammability standards, smoke toxicity in case of fire, etc. We don't just open our catalog and they pick a device. The customer specifies a size and their requirements and each time we must do a new set of calculations."

Under all these circumstances, BLOCK found it increasingly more difficult to design inductors and transformers with aging simulation software. To save costs and in order to provide improved services to their customers, the company needed to find a way to reduce the number of prototypes it created before finalizing a design.

With this in mind, the company turned to the COMSOL Multiphysics® software for its ease-of-use, flexibility, and HPC (high-performance computing) capabilities.

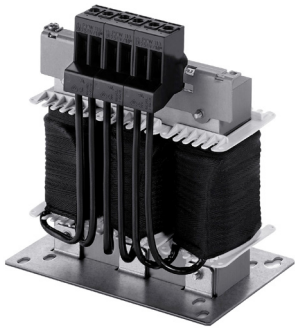
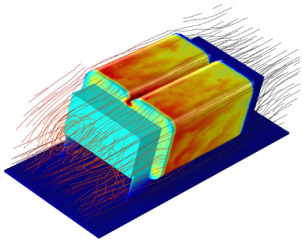


FIGURE 1: Layout of a line reactor used to filter out spikes of current and reduce injection of harmonic currents into the power supply.



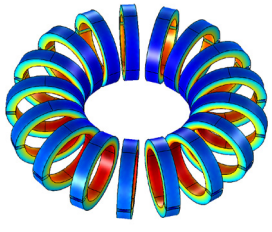


FIGURE 2: Simulation of an air cooled DC choke where temperature distribution and velocity streamlines are shown (top). Magnetic flux density in a toroidal choke (bottom). Its inductance is numerically determined as a function of inner and outer radius and wire thickness.

"We can model new devices and find critical areas, where, for example, electromagnetic losses are high or the temperature of the device reaches some threshold," said Siatkowski. "With COMSOL Multiphysics, we can identify these areas and simulate the relevant physics effects so that we can quickly and accurately find ways to improve the design."

The research department is analyzing magnetic characteristics and hysteresis losses in several soft magnetic materials in the BLOCK testing laboratory. One of the main reasons the company uses COMSOL® software is that it allows them to easily insert their own formulas developed over years for all these characteristics and to use them for their simulations.

» HPC LEADS TO GREATER THROUGHPUT

IN ADDITION to using multiphysics simulation, BLOCK is benefiting from the HPC capabilities that COMSOL Multiphysics offers: they can run their simulations on a multicore workstation with no limit to the number of cores and on a cluster with no limit to the number of compute nodes. This offered them improved efficiency regardless of whether a simulation is run on a workstation or a cluster; their R&D team can now quickly deliver the best products to customers.

Siatkowski uses COMSOL to set up models for many of BLOCK's devices, which are often difficult to calculate analytically, but have a geometry that can be based on a few parameters and specific customer's needs. One example of a model that

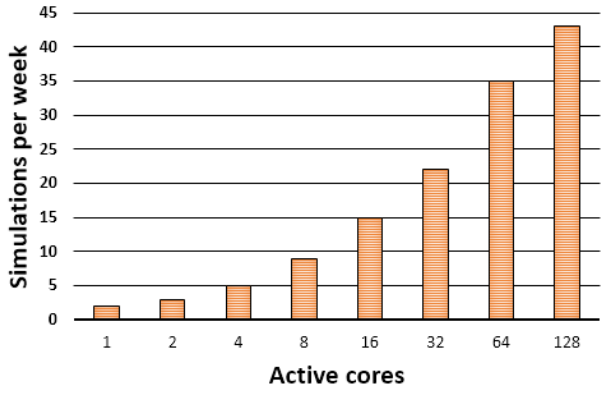


FIGURE 3: Moving from a single workstation with eight cores to a modestly sized cluster can lead to a significant performance increase.

Siatkowski built was for a DC choke (see Figure 2).

"With COMSOL Multiphysics, I can run a simulation that has parameters like width, height, thickness of the wires, etc. and explore the entire design space defined by our teams and customers. Our product developers and sales teams can now work more efficiently and easily find the best solution," explained Siatkowski.

» IT'S ALL IN THE ARCHITECTURE

"FOR SMALLER MODELS, I can build a model on my workstation and run the computation there," explained Siatkowski. "But for the larger models, my workstation is not fast enough and does not have enough memory."

This is when the flexible nature of COMSOL came into play and BLOCK fully benefited from the available HPC capabilities supported by the software architecture and generous licensing. Siatkowski instead runs his models on several computers with multiple cores.

"I'm currently using a cluster with 22 cores and 272 GB of RAM and I can easily run my simulations remotely on it," said Siatkowski. "COMSOL supports distributed memory computing where each node of a cluster can also benefit from local shared memory parallelism; this means that I'm getting the most out of the hardware available." The speedup obtained in terms of simulations per week for a large electrical study is shown in Figure 3.

After executing the simulation on the high-performance computer, Siatkowski reviews the result on his workstation, where he can then also perform postprocessing. "The benefit of this is that during the simulation itself, my workstation is free and I can continue with other work and even do pre- or postprocessing on other models. The architecture that the COMSOL software has allows us to be more productive and service our customers better."

From left to right: C. Kliesch (Bachelor Student), Dr. M. Siatkowski (Advanced R&D), M. Owzareck (Advanced R&D), A. Bimidi (Student Apprentice), Y. Kumar (Master Student), Dr. D. Kampen (Head of Advanced R&D)

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These tools allow our engineers to tailor our designs to meet customers' needs with minimal time and input. In the past, these recurring analyses took hours and required an employee specializing in simulation; with a COMSOL application, employees at all levels of our organization can run simulations nearly effortlessly.

All told, multiphysics simulation and application design through COMSOL allows our designers to make better, more competitive products. Efficiency is core to our company philosophy—doing more, using less. This is not limited to the efficiency of our products, but also in the way we conduct business, generate ideas, and create new designs. The Application Builder is now a vital element in helping APEI build the best wide band gap solutions possible.

BRICE MCPHERSON *is a senior engineer at APEI, with 11 years of experience in high performance, extreme environment wide band gap power semiconductor packages. He specializes in the parametric CAD design and analysis of APEI's power modules and conversion systems.*