Driving Down Time to Market

Danfoss drives are compatible with all shown motor types.

More than 50% of the world's electrical energy goes into powering the electric motors that spin up everything from simple compressors in HVAC to high-precision positioning and synchronization operations in the food and beverage industry. AC drives control the speed of these motors, so bringing more efficient AC drives to market is critical to improving energy efficiency. Danfoss A/S, one of the world's largest manufacturers of AC drives, is dramatically reducing time to market for its new AC drives using Ansys Sherlock.

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Reliability Physics and FEA: A Perfect Match in the Electronics Industry
Ansys.com/fea-electronics

The world turns on electric motors. They power everything from subway wheels to big turbines, from escalators to baggage carousels. With so many uses, electric motors are often required to operate at varying speeds and torque levels to suit application demand. For example, when there are few or no bags on the carousel at the airport, there is no need for the carousel motor to spin at its top-rated speed or torque and waste electricity.

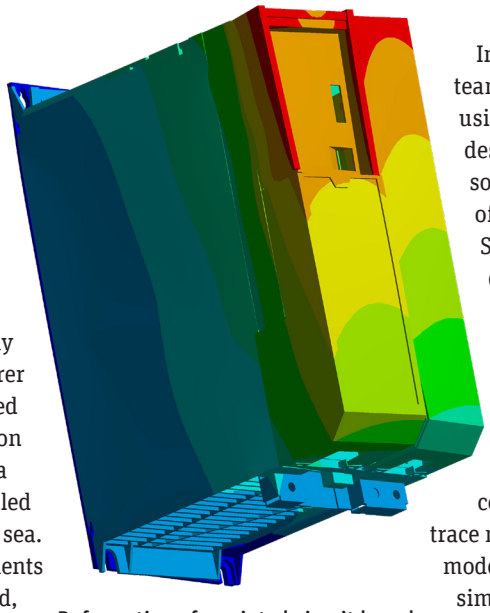
With so much of the world's electrical energy being used by electric motors, anything that more effectively regulates power to them helps reduce energy waste. That is where AC drives from Danfoss A/S come into play. AC drives — also known as adjustable or variable speed drives, variable frequency drives, frequency converters, inverters and power converters — control the speed of electrical motors. Danfoss drives play a key role in the development of smart communities by helping to deliver an uninterrupted, temperature-controlled supply chain, a fresh food supply, building comfort, clean water and environmental protection. In all, the company's line of AC drives has thousands of variants to cover the widest range of applications from a fraction of a watt to several megawatts. Engineers in its R&D facilities — in the United States, Germany, India and China, as well as in the company's headquarters in Graasten, Denmark — work constantly to bring new and more advanced AC drives to market.

The product development cycle for a new AC drive can stretch out several years. Danfoss engineers wanted to explore ways to bring new products to market faster, which led them to Ansys Sherlock automated design analysis software.

SUBSTITUTING THE VIRTUAL FOR THE PHYSICAL

One of the great challenges in the world of AC drives is that different customers may use the same AC drive in a wide range of deployment scenarios. The same AC drive that one manufacturer uses in a line of washing machines may be used by another manufacturer in a line of radar arrays destined for use in an outdoor installation above the Arctic Circle — or in a line of bilge pumps to be installed in the engine room of a ship at sea.

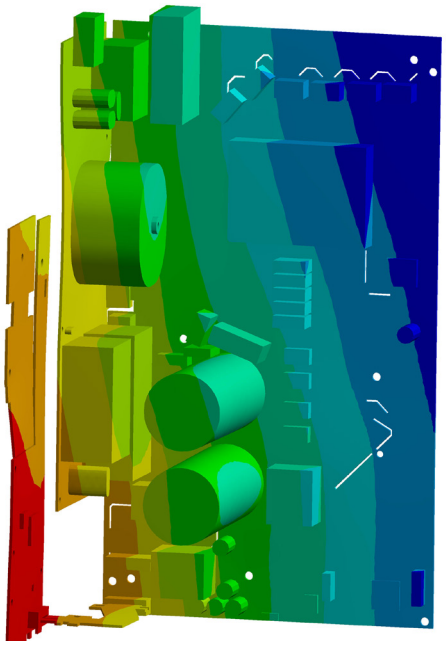
Given the range of environments where an AC drive might be used, the reliability engineers at Danfoss are always testing for drive failure due to solder fatigue arising from thermal, mechanical or physical stresses (vibration, bumps or shocks). If a prototype fails to meet reliability expectations, the team needs to identify the point (or points) of failure, refine the design, build another prototype and retest the drive — and repeat this process three, four or more times until they are confident that the new design will perform in all specified scenarios. Unfortunately, because of the time required to construct a new drive prototype for testing — even if a design modification is slight — each iteration of this design–manufacture–test cycle might take six to eight months to complete. Four design iterations of a single drive might stretch time to market by two or more years.



Deformation of a printed circuit board assembly and components inside a drive using Ansys Mechanical. Red represents maximum displacement and blue represents minimum displacement.

In 2014, though, the company's team of reliability engineers began using Ansys Sherlock automated design analysis software to predict solder fatigue in virtual prototypes of its new AC drive designs. With Sherlock, the reliability engineers do not need to wait for physical prototypes to conduct their tests. They simply load the electronic computer-aided design (ECAD) files into Sherlock. Within minutes, Sherlock automatically translates the file's data about components, placements and trace maps into a 3D finite element model. The software then performs simulations on that model based on thermal, mechanical and other parameters that the Danfoss engineers define. Danfoss engineers integrate these printed circuit board assembly (PCBA) finite element models into Ansys Mechanical to perform simulation on the system level. The stress and strain results from the system-level simulation are then used in Ansys Sherlock automated design analysis software to perform reliability risk analysis. Upon completion of the simulation, Sherlock provides the reliability engineers with a map of the components examined that shows how long each part is likely to last.

If the results provided by Sherlock indicate that the tested design is not likely to perform as reliably as the specs demand, the designers can immediately refine the virtual model. As soon as the refinement is



A vibration simulation on a complete drive assembly is shown in Ansys Mechanical. Red represents maximum displacement and blue represents minimum displacement under vibration load.

done, the reliability engineers can reload the refined design into Sherlock and run the simulations again. While Danfoss still produces physical prototypes at different times during the design phase, the reliability engineering team does not need to wait for physical prototypes to perform its reliability risk analysis. Danfoss engineers now cycle through design iterations so quickly that they target bringing new drives to market in less than half the amount of time that it used to take — and delivering higher product reliability right from launch.

MORE INSIGHT INTO MORE APPLICATIONS

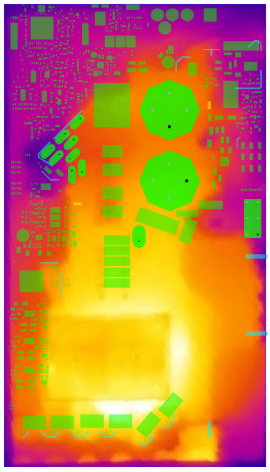
With Ansys Sherlock, Danfoss engineers can conduct far more virtual tests than before. Instead of physically replicating the thermal variances associated with an arctic radar station or the vibrational characteristics of a spinning washing machine or a ship at sea, Danfoss engineers have developed a library of application load profiles that they can use in Sherlock to simulate these and many other scenarios. It takes only a moment to load a scenario, and most simulations take only three to four hours to complete. When testing physical prototypes, it might have taken Danfoss engineers months or years to set up and run some of these tests.

The benefit of being able to draw upon such a library of simulations is noteworthy in other ways. When Danfoss engineers worked exclusively with physical prototypes, they had neither the time nor the budget to test each prototype in all different usage scenarios. Therefore, Danfoss would occasionally find itself in a position where it had to accept returns from customers whose drives had failed when used in untested scenarios. Today, because the design team can quickly run so many different simulations in Sherlock, Danfoss is seeing far fewer drives being returned due to failure in untested situations. Overall product reliability is improved, as is customer satisfaction.

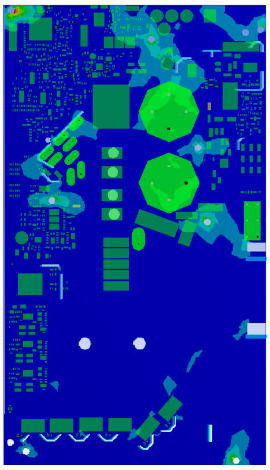
ANTICIPATING FUTURE SAVINGS

Danfoss has a long-standing commitment to responsible environmental stewardship by fostering more efficient use of electric power. By bringing new AC drives to market faster, Danfoss enables customers around the world to accelerate the uptake of these energy-saving devices. In turn, that means the wide range of products that require electric motors can operate more efficiently and waste less power. The baggage carousel does not need to draw more power if there is less luggage — or no luggage at all.

When 50% of the world's electrical power is spent powering electric motors, the opportunity for power leakage and energy waste is rampant. With Ansys Sherlock accelerating the process, Danfoss is spinning up a new set of solutions that can help make the world a more efficient consumer of the electricity it relies on.



Temperature distribution due to power losses on the component and in the PCB tracks used for solder joint fatigue life estimation. The components in green show no risk of solder joint fatigue; those in yellow show marginal risk. Several design iterations were performed to achieve acceptable lifetime results.



Ansys Sherlock displays strain distribution on PCBA from system simulation and solder joint or component cracking risk analysis. The components in green reveal that there is no risk, a result achieved after several design iterations.