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Journal Article

Multiphysics Simulation Key to Superior Traction Motor Performance

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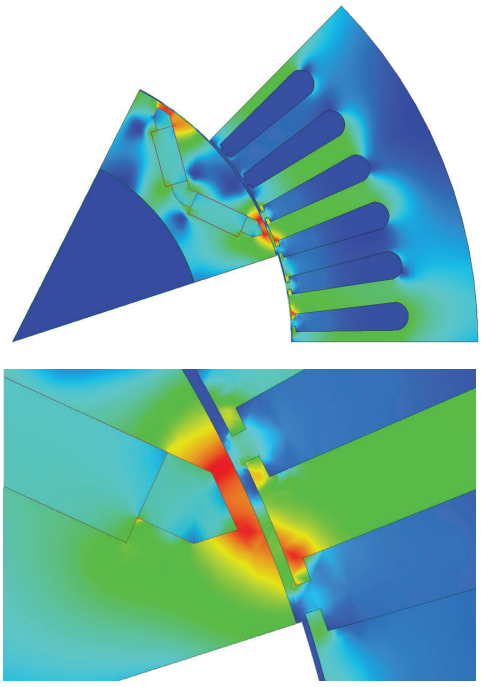
Automobile original equipment manufacturers (OEMs) face the difficult challenge of designing a new generation of traction motors – which play a critical role in hybrid electric vehicle (HEV) and electric vehicle design – by transforming electrical energy into physical energy used to turn the wheels of the vehicle. The efficiency with which traction motors can perform this conversion is critical because of its impact on the range and battery life of the vehicle. Another design challenge is the need to minimize rare earth metal content, since these materials are increasingly in short supply.



Finite element analysis accurately accounts for nonlinearity and local saturation of a rotor and stator. Maxwell® electromagnetics field simulation software from ANSYS® uses the finite element method to solve static, frequency-domain and time-varying electromagnetic and electric fields. A key benefit of the software is its automated solution process in which users need specify only geometry, material properties and desired output. From this point, Maxwell automatically generates an appropriate mesh for solving the problem.

OEMs face a huge number of possible combinations of the many design parameters involved in traction motor design. For example, at the highest level, they need to determine whether an interior permanent magnet, induction machine or switched reluctance machine design is the best fit for the vehicle.

The traditional method of designing traction motors involves building and testing prototypes to evaluate each design alternative. The weakness of this approach is that the cost and time involved means that engineers can study only a few design alternatives; thus, they cannot optimize motor performance to its full potential. Simulation enables engineers to study hundreds of thousands of design alternatives so they can iterate to a traction motor design that will deliver a much higher level of efficiency while meeting constraints and requirements.

So OEMs use multiphysics engineering software to develop virtual prototypes of traction motors that help them understand how a particular design alternative will behave without having to build physical hardware. The first phase of the design process, typically, is to study the electromagnetics of the electric machine using electromagnetic field simulation. These tools compute the torque profile of the machine. Design parameters such as magnet size and geometry are varied to optimize the trade-offs between performance and efficiency against size, weight and cost.

In the early stages, engineers gain an understanding of performance trade-offs in each individual domain involved in traction motor performance — electromagnetics, electrical, thermal, electromechanical, controller, etc. Later, they begin to tie together multiple domains into a single simulation so that they can simultaneously optimize different domains.

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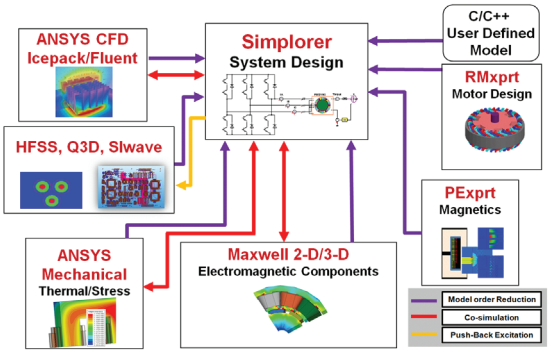

A systematic, integrated simulation approach for motor and drives systems, ANSYS Simplorer® is a multi-domain system simulation program used for designing high-performance systems that include electrical, thermal, electromechanical, electromagnetic, controller designs, etc. Simplorer ties all these different physical analyses together to ultimately optimize the whole electric powertrain as one coherent system. This figure shows the resulting design flow.

For example, traction motors can be a major source of noise in electric vehicles. So the computed torque output generated by electromagnetics simulation is used in a structural mechanics solver for computing mechanical stresses, loads, deformations and vibration of the powertrain. A fluid dynamics solver is used to study thermal management issues, mapping energy losses and determining heat distribution in the motor/generator assembly.

Another multiphysics simulation example calculates stress and deformation on the stator lamination and coils and uses the results to perform vibration/acoustic noise or fatigue analysis. The simulation predicts the amount of noise generated by the traction motor as well as its operating life.

Simulation-driven development provides the ability to rapidly evaluate many traction motor design alternatives and to predict their performance in a short amount of time. Engineers at leading HEV and EV manufacturers are using multiphysics-based simulation tools to produce superior traction motor designs and bring them to market ahead of competitors.

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