

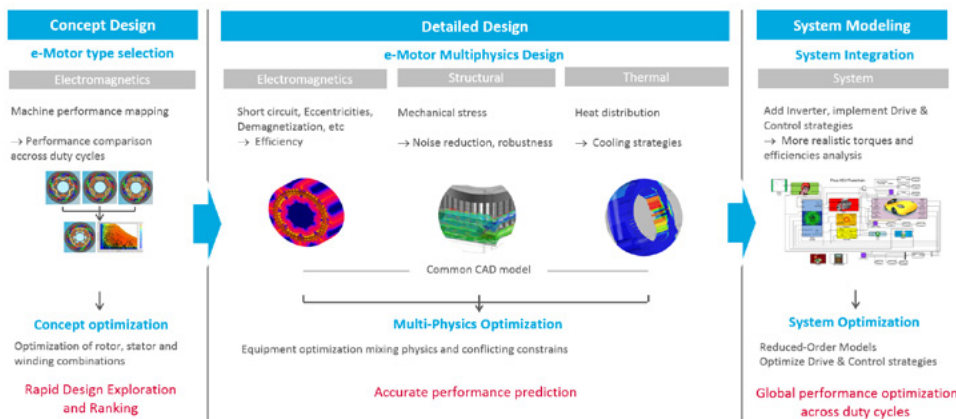
E-MOTOR DESIGN USING MULTI-PHYSICS OPTIMIZATION

The design of a high-performance e-Motor is a complex undertaking. Engineers have conflicting constraints to consider including efficiency, temperature, weight, size and cost. To explore more ideas, better understand their designs and improve performance, Altair HyperWorks™ has a workflow to guide motor designers through an efficient process of Simulation-Driven Design. This analysis and optimization solution supports multi-disciplinary teamwork and reduces design times.

Concept Design

Engineers starting from a clean sheet need a tool that helps them select a design direction quickly. Altair FluxMotor™ is an easy-to-use software, dedicated to the concept design of electric rotating machines. It enables a designer to build a machine from standard or customized parts then add windings and change materials. Quick multiphysics tests can be run to assess machine performance. Comprehensive analysis and reports includes efficiency, NVH and thermal predictions.

By coupling FluxMotor with Altair HyperStudy™ more design exploration and optimization can be accomplished. FluxMotor can predict the machine performance at one or more working points, or over a complete duty cycle. Using these tools confidence can be established in meeting requirements, even at this early design stage.



Detailed Design

Whether starting from a concept or an existing design, Altair Flux™ enables engineers to simulate, improve, and optimize electrical machines. The software provides detailed analysis with high-fidelity models. Powered by best-in-class numerical techniques, Flux delivers accurate analysis of motor behavior, considering eccentricities, demagnetization and the effects of the manufacturing process.

Flux simulates not just magnetic static, steady state and transient conditions, but also electrical and thermal properties. Simulations take into account machine properties – including inertia, friction and drag torque – to calculate real-world speed and torque performance.

Multiphysics Analysis and Optimization

The Flux connection to Altair SimLab™ provides easily coupling to different models and physics. This process-oriented environment enables automated workflows, sharing the same model and design variables for each physics. HyperStudy is able to connect the various physics together in a single optimization loop.

Learn More at:
altair.com/flux

ElectroMagnetic-Structural Coupling

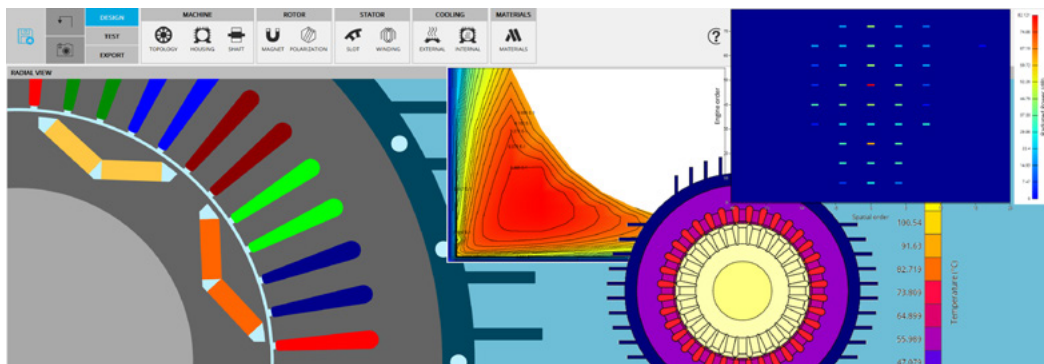
Altair OptiStruct™ is an industry proven, modern structural analysis solver for linear and nonlinear events. It is the market-leading solution for structural design and optimization. Flux can export electromagnetic forces to OptiStruct for vibration analysis.

Engineers can evaluate the modal frequencies and run an optimization to improve performance. The Flux-OptiStruct combination is not just important to noise reduction, it can also minimize the mechanical stress on the motor structure and mounts to improve durability. When required structural interaction with an entire driveline system, including the gears, transmission and chassis, can be simulated.

ElectroMagnetic-Thermal Coupling

The Flux software has its own thermal solver that can be coupled to the electromagnetic solver. Both static and transient analysis can be considered with exchange coefficients to define convection and radiation effects.

For higher fidelity analysis of convection effects, Flux couples with Altair AcuSolve™. This provides powerful fluid flow analysis capabilities; hot spots can be identified, and design alternatives studied. Altair nanoFluidX™ is a particle-based fluid dynamics tool to predict the flow in complex geometries, including oil flow simulation in gearboxes. It delivers fast solution times and a simplified workflow that makes advanced simulation possible by non-CFD experts.



FluxMotor dedicated environment for exhaustive motor design exploration

System Integration

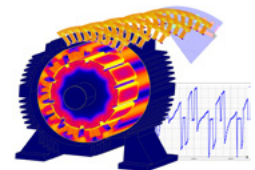
The transient performance of an electric machine is highly dependent on its drive. Simulation of the entire drive system, motor design, power electronics and controls, can be achieved in Altair Activate®. Activate is a multidomain system simulation environment enabling the generation of accurate transient operating conditions. Coupling the model of a power inverter and pulse width modulation control for a multi-phase motor, or other complex inputs requiring the modeling of power electronics and detailed algorithms, enables losses and torque ripples to be better understood. The losses effect efficiency and the thermal behavior, and the torque ripples cause speed pulsations and vibration problems.

Activate can also simulate the motor without coupling using tables exported from FluxMotor or Flux for fast evaluation of electronics and controls design alternatives. In addition, equivalent thermal circuits extracted from Flux can be used in Activate. This enables an engineer to model motor thermal behavior quickly and can predict temperature profiles during duty cycles.

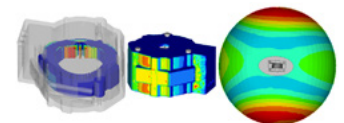
Solution Summary

This Simulation-Driven Design approach supports the development of e-motors using a series of optimization intensive phases building on each other:

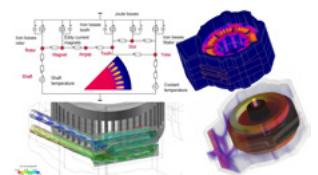
- Early concept design and the choice of baseline machine focuses on the optimal combination of stator and rotor layout based on electromagnetic, thermal and NVH design criteria.
- Detailed design with multi-physics refines the design, considering criteria from different domains; electromagnetics, structural mechanics, and heat transfer.
- The last phase adds essential components and systems into the design process to improve accuracy and converge on an e-Motor design integrating it into a complete e-powertrain.



Flux 3D modelling capabilities
(Courtesy of Ik4-IKERLAN)



Seamless coupling within the
Altair platform fosters efficient
analysis for noise reduction



Altair offers complementary
thermal modeling solutions
for all stages of design