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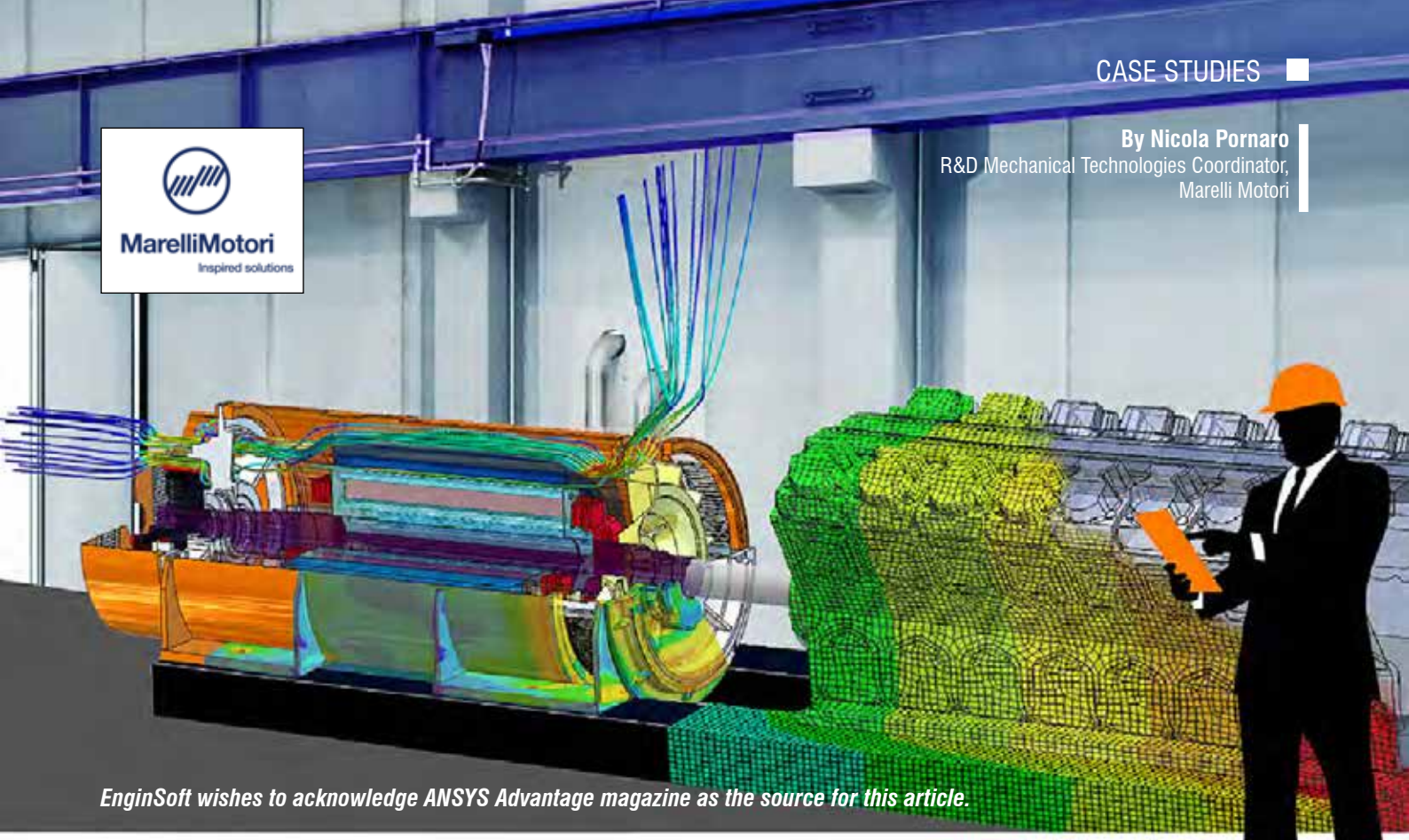

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Electrifying Solutions for Motors and Generators

The market for electric power generation equipment is growing more competitive every day, with customers demanding more reliable, eco-friendly products at lower cost. Marelli Motori meets these demands using ANSYS Maxwell, ANSYS Mechanical and ANSYS CFD in multiphysics simulations to deliver the tailor-made solutions their customers have come to rely on. More recently, they have begun using ANSYS Discovery Live to obtain instantaneous simulation results with every on-the-fly change to a product's geometry or operating conditions, greatly reducing design time.

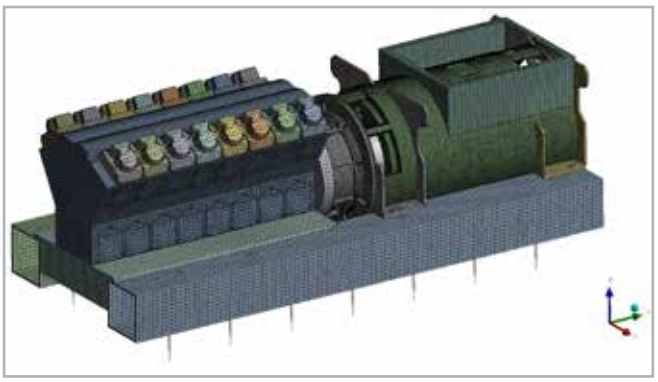
Electric motors and generators contain rotating magnetic coils through which electrons flow. The resistance of electrons flowing through wires, together with the friction generated by rotating devices, causes heat to build up. Energy lost as heat is unavailable to do work, reducing the efficiency of the motors and generators. Excess heat can also cause structural problems as temperature builds up in structural components and induces stress. Heat can be dissipated with cooling airflow, but the physics of the airflow must be optimized for maximum effect.

Because all these physical effects are happening simultaneously, a multiphysics simulation approach is needed. Marelli Motori engineers use ANSYS multiphysics solutions to custom-design motors and generators to solve challenges in hydropower, cogeneration, oil and gas, civil and commercial marine transport, military applications, and ATEX applications involving motors and generators in explosive atmospheres, among other applications. (ATEX consists of two EU directives describing what equipment and work space is allowed in an environment with an explosive atmosphere.)

Mechanical, Flow And Electromechanical Multiphysics Solutions

Marelli Motori engineers use ANSYS Mechanical to optimize the design of the frame, shields, cooling fan, motor shaft and generators. Structural simulations focus on reducing the weight of these components while optimizing stiffness. The R&D Team of Marelli Motori also simulates the response of the machine to the static and dynamic forces that are generated by the rotation of the rotor; excessive forces could lead to

"When simulating a heat exchanger on a closed alternator, an experienced ANSYS CFX user analyzed five different designs in eight hours; with ANSYS Discovery Live, the same engineer reached an optimal design in two hours."



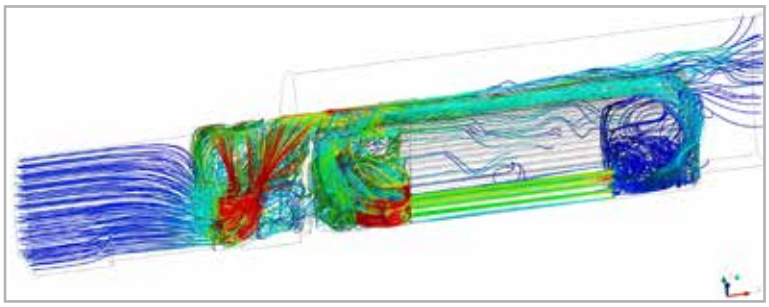
Example of a genset with Marelli Motori's alternator installed in a hospital in Germany

component failure through deformation, crack formation or fatigue. Using ANSYS Workbench as a common platform to perform multiphysics simulations, Marelli Motori engineers run ANSYS CFX simulations along with structural ones to determine the design that best combines optimal structural integrity, thermal efficiency and cost reduction. The rotor assembly (including single or double cooling fans, depending on the machine air circuit), the stator and the heat exchangers (when needed) are the core thermal exchange components of the motor or generator. ANSYS CFX computational fluid dynamics (CFD) simulations increase the cooling efficiency and thermal exchange with the surroundings by optimizing the airflow through the machines. This reduces hot spots inside the generators and motors to increase efficiency and maximize power output.

Finally, adding ANSYS Maxwell to Mechanical and CFX in multiphysics simulation completes the optimization process. The only way to reduce forces that create motor vibrations is to extract the magnetic forces using Maxwell and export them into a Mechanical analysis to evaluate the harmonic response of the frame. Maxwell is also used to identify hot spots in the coils and combine this analysis with a CFX calculation to locally optimize the design and improve the heat exchange. ANSYS Multiphysics simulations yield higher-quality results in 60–70 percent less time than other simulation products that Marelli Motori engineers have used in the past.

Manufacturing Challenges

Even after the design has been optimized using mechanical, flow and electromechanical simulations, the challenge of building the motor or generator most efficiently and effectively remains. Marelli Motori engineers want to facilitate the construction operations while keeping mechanical safety and reliability for each operating condition firmly in mind. This is the most challenging part of the engineering workflow, because while the engineers are trying to design a family of components to optimize heat extraction from the machine, they must simultaneously consider constraints regarding shape feasibility, production cost and ease of final assembly. Using ANSYS Mechanical and ANSYS CFX together in a multiphysics simulation guides the engineering team to the best manufacturing process. A recent project to develop a new series of small alternators with the latest technological improvements took much less time using ANSYS simulation.

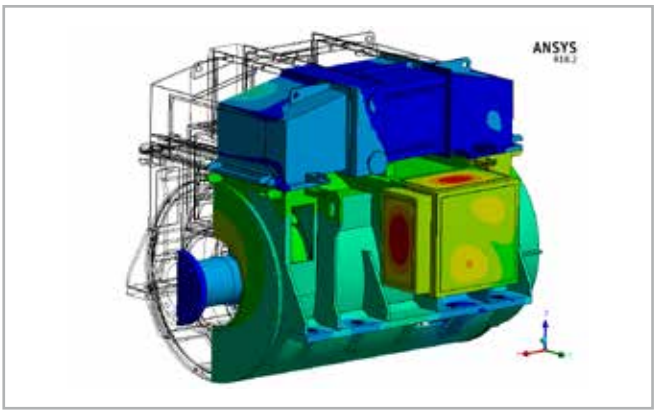


All the CFD simulations that lead to a redesign are subsequently evaluated in a test room. Here, some of Marelli Motori's motors for industrial applications are being tested.

Application Examples

Obviously, the importance of the various design parameters changes with each application. In marine applications, motors and alternators must be silent with very low vibrations to avoid ruining the experience of the ship's passengers. Structural finite element analysis and harmonic response calculations using ANSYS Mechanical must be performed on the frame and other components to reduce sound and vibrations.

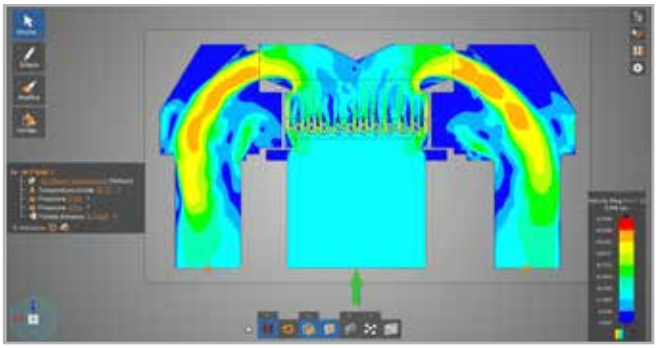
A genset is a combination of an internal combustion engine with an electric motor or alternator, used as a standby electric power supply. Vibrations from the diesel engine can excite natural frequencies and harmonic responses in the system. Marelli Motori engineers run modal analysis in ANSYS Mechanical to find these frequencies and harmonic responses, which vary according to operating conditions, to analyze the dynamic behavior of the alternator. This is followed by a collaboration between the customer and the genset designer to avoid any possible resonances of the entire genset with the surrounding structure for each design project. If this upfront analysis was not done, and the completed genset generated vibrations and structural noise inside a vessel,

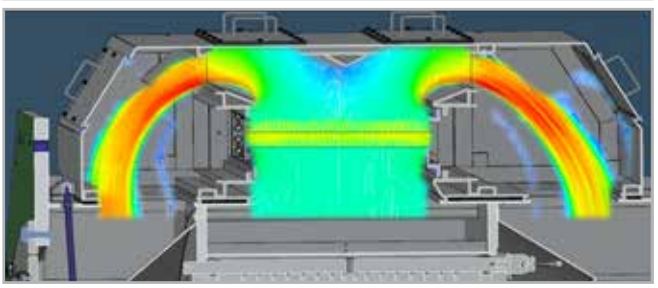


Max power generator in a marine application and simulation of its alternator

correcting the problem would result in tremendous additional costs and project delays.

In power generation applications, increasing efficiency is the most essential step. This mainly involves applying CFD simulations to improve the airflow to cool the machines and coupling the results with EM simulations that optimize the electrical parts by reducing losses. Marelli Motori engineers perform this multiphysics simulation daily. All modifications introduced after numerical simulations are evaluated in a test room to demonstrate benefits in terms of temperatures and efficiency according to international norms.





Example of a heat exchanger simulated using ANSYS CFX. An expert user completed five simulations in eight hours. Using ANSYS Discovery Live, a user completed many simulations in two hours to achieve an optimal design.

"The engineers used ANSYS Maxwell to identify hot spots in the coils and combined this analysis with an ANSYS CFX calculation to improve the heat exchange."

Using Simulation For Ideation

Marelli Motori was one of the first companies to adopt ANSYS Discovery Live when it was released early in 2018. Discovery Live is the first simulation solution to enable engineers and designers to make changes to geometry and other properties while a simulation is running and instantaneously view the results of these changes. With their commitment to promptly satisfy their customers with high-quality, reliable, customized products, Marelli Motori realized that such rapid simulation results would help them to react to their customer's needs faster. In one case involving simulation of a heat exchanger on a closed alternator, an experienced CFX user analyzed five different designs in eight hours; with Discovery Live, the same engineer reached an optimal design in two hours, a savings of six hours. ANSYS multiphysics simulations helped Marelli Motori engineers to design the best components for their customized electric motors and generators and become more competitive in the worldwide market. Their customers appreciate the increased efficiency, cost reduction and shorter development times, along with the greater reliability provided by the synergy between Marelli Motori and ANSYS simulation. ***www.marellimotori.com***

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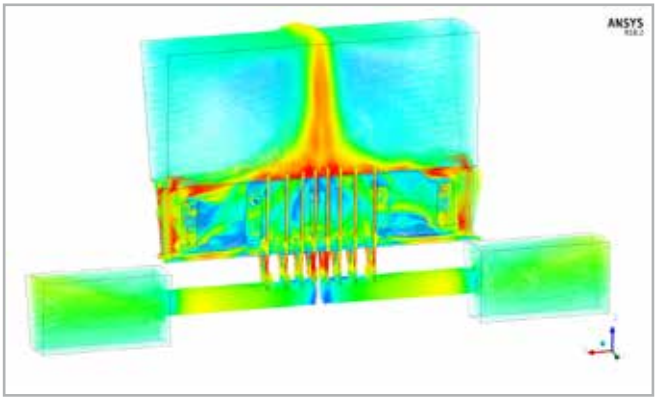
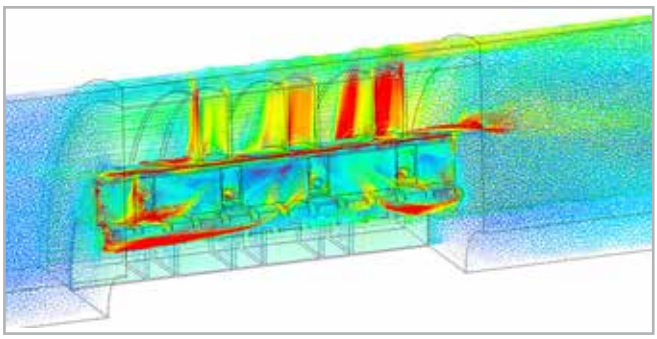


ANSYS CFX is used to optimize the cooling channels inside a rotor.



ANSYS CFX rotor simulation