

Energizing Generator Designs

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Generators serve as the heart of hydroelectric power plants and must be accurately designed to optimize energy output and prevent excessive temperatures that cause energy losses and shorten the machine's life. Leveraging ANSYS simulation and an improved workflow, INDAR engineers improve generator design accuracy and accelerate all stages of their simulation. This allows them to meet tight delivery deadlines and significantly scale generator production.

Providing the world's largest source of renewable energy generation, hydropower delivers clean, affordable and reliable energy. Among renewable energy sources, hydropower is only second to wind in offering the lowest carbon emissions per kilowatt hour.

Generators are the heart of a hydropower plant's electricity production process and must reliably optimize energy output.

Excessive heat within the generator, known as hot spots, can lead to energy losses or even shorten the life of the machine.

Established in 1940, INDAR, an Ingeteam company, is a leading power conversion partner for its customers: energy generation (generators for wind,

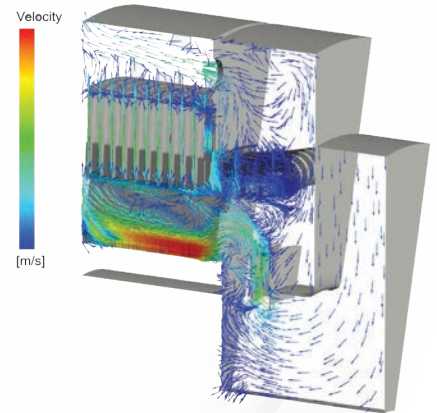
◀ An ANSYS Fluent simulation determined the temperature profile of the active parts of a salient pole generator.



ANSYS Fluent Mosaic Technology
[ansys.com/mosaic-meshing](https://www.ansys.com/mosaic-meshing)

hydro, internal combustion, steam and gas), marine electric propulsion (motors and generators), industrial drives (motors) and submersible water pumping (motor pump sets). Producing physical prototypes of many of the highly complex hydroelectric generators of enormous size manufactured by INDAR is too costly and impractical. Instead, engineers rely on simulation and in-house analytical tools to produce a version of the generator to satisfy tight delivery timelines. INDAR leverages ANSYS Mechanical, ANSYS Maxwell and ANSYS Fluent simulations to create designs that ensure the performance of these machines. Many of INDAR's hydropower generators are nonstandard designs that must be customized according to each customer's requirements. This level of customization requires flexible, comprehensive and accurate engineering simulation.

The team's recent adoption of ANSYS Mosaic technology to enhance the Fluent meshing workflow has greatly accelerated all stages of the team's simulation work. Automation has cut hands-on development time because preprocessing time has been reduced from six to eight days to four hours, and solving time has been slashed by 30%. This greatly speeds up production as each design variation requires only one day to be analyzed instead of more than a week.



ANSYS Fluent simulation of the velocity profile of a generator helps to ensure adequate cooling airflow.

“INDAR engineers can meet performance targets in less time so they can explore a larger number of options to further improve the generator.”

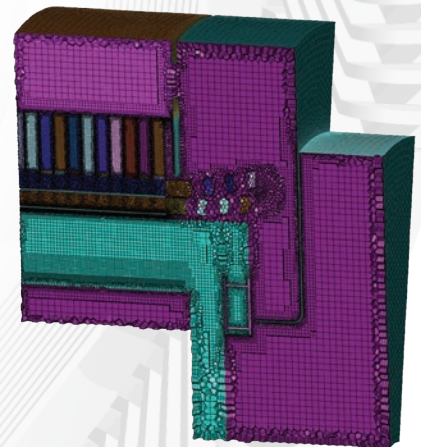
GENERATING THE DESIGN

INDAR engineers use ANSYS Maxwell simulations to verify and optimize the electromagnetic design of the electric generator. The team begins the process with RMxpert — an analytical sizing tool included within Maxwell — to parameterize many dimensions of the generator and run hundreds of what-if scenarios, examining many operating conditions in a matter of seconds to form a preliminary design.

Engineers then use ANSYS Maxwell to simulate the best candidate configurations from the preliminary design for electromagnetic behavior. This guarantees that the generator will perform optimally. The team reduced electromagnetic design time from three days to one by using ANSYS electromagnetic field technology.

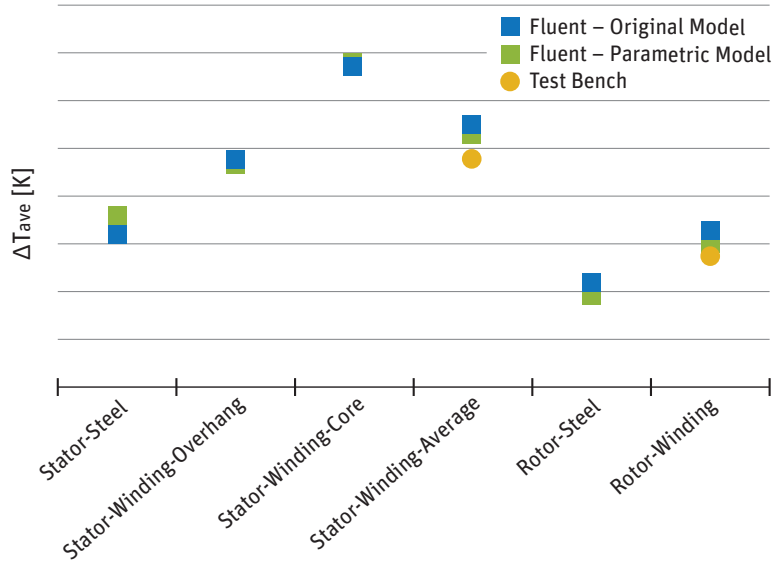
To ensure that the machine operates reliably throughout its service life, engineers next must validate the generator's cooling system to prevent the machine from reaching unacceptably high temperatures. Optimization of the cooling circuit helps to improve the efficiency of the generator by reducing mechanical and cooling losses. To demonstrate that the heat can be released without affecting the behavior of the generator, INDAR engineers use multiphysics simulations by applying the heat-induced electromagnetic losses calculated by Maxwell, as well as inlet temperatures and thermal boundary conditions in ANSYS Fluent, to run a thermal analysis.

To obtain the velocity fields and thermal profiles, engineers employ Fluent simulation. Velocity fields are required to ensure adequate air flow throughout the entire generator to cool the heat generated by the electromagnetic parts. They also want to prove there are no stagnation points where the air does not flow or any spot where there are excessive velocities, which can cause large pressure drops or other issues. Engineers also review thermal maps to identify potential hot spots to confirm that the



Mosaic-enabled poly-hexcore mesh

“Preprocessing time has been reduced from six to eight days to four hours and solving time has been slashed by 30%.”



Temperatures obtained using the old workflow (starting from design drawing). The new workflow (parametrized model) and the measurements from the test bench were in agreement.

designed cooling flows can keep the machine’s parts below the established temperature limits.

INDAR engineers use the simulations they perform in Maxwell and Fluent along with their in-house analytical tools to study generator designs within minutes.

FAST AND AUTOMATED MESHING

Meshing generators of such dimensions is challenging because of the difference in scale. The mesh must accommodate small air gaps between the rotor and stator (measuring a few millimeters) where accuracy is paramount, as well as the much larger overall length and diameter of the generator and cooling system. Some of these dimensions can reach 4.5 meters.

The need to simultaneously solve turbulence and energy equations requires creation of a conformal mesh between the fluid and the solid parts.

Engineers must also accurately capture the heat transfer in the boundary layer. This requires a mesh with an inflation layer, which adds more levels of complexity when building the mesh.

The ANSYS Fluent simulation is expedited by a task-based workflow and Mosaic-enabled poly-hexcore meshing technology. Engineers employ ANSYS SpaceClaim to process the geometry created in Maxwell and CAD for CFD simulation, then mesh the generator. INDAR engineers have also developed a parametric geometry model that allows them to build their 3D generator geometries within minutes thanks to ANSYS SpaceClaim, by just filling in the generator dimensional specifications in a table

within ANSYS Workbench. This workflow greatly accelerates all stages of the simulation from meshing to solution. The team can reduce preprocessing time from six to eight days to less than four hours and generate an answer to a specific design question using 30% less solver time.

Mosaic meshing technology yields improved accuracy and higher-quality meshes with 15% fewer cells and requires half the time to solve when compared to previous methods. Prior to leveraging Mosaic, engineering



teams applied traditional mesh topologies like tetrahedral elements. These meshes excelled in flexibility and process robustness but were less than optimal in solving for performance and accuracy. Automation was possible, but engineers needed to write, understand and maintain scripts, which required a specific expertise. In addition, to explore a slightly different scenario, a standard script had to be modified using a trial-and-error approach. These steps have been largely eliminated through the new meshing workflow that allows the team to create customized templates in a quicker and automated way.

Mosaic technology automates many of the standard and repetitive meshing tasks to greatly reduce the engineer's hands-on development time, improve productivity and speed up the time to create high-quality CFD mesh. Automation has been a real game changer as it empowers engineers at any level of experience to quickly develop designs because Mosaic does much of the work. The engineer defines the most appropriate inputs for the type of physics required to get the desired mesh at a fraction of the time that it formerly required.


Mosaic reduces the overall number of cells, and the poly-hexcore cells in the bulk regions reduce the number of equations, leading to a faster solve time. Poly-hexcore is more efficient than the tetrahedral meshing the team previously used.

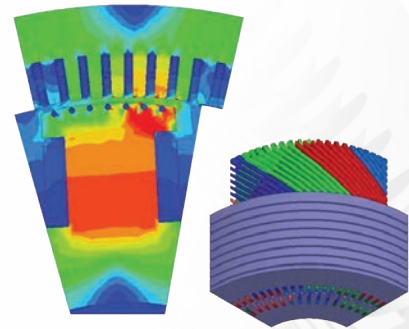
The team can increase meshing speed even more by using parallel processing so that meshing creation can be accelerated up to 10 times by applying multiple cores during the mesh generation process.

INDAR engineers have verified the accuracy of the ANSYS thermal simulations by comparing the results to their test-bench air flow, mechanical loss and temperature measurements. The results confirm that the simulation models predict the measurements with great accuracy.

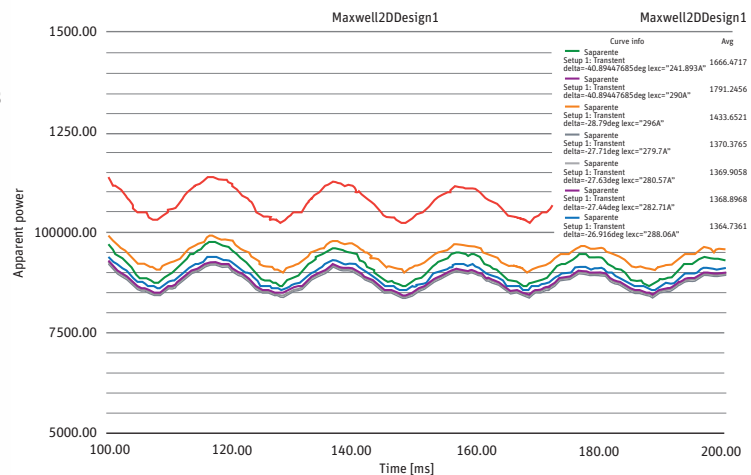
As a result, INDAR engineers can meet performance targets in less time so they can explore a larger number of options to further improve the generator.

INDAR uses ANSYS simulation to model many of its generator types, perform modifications to existing designs and study the influence of new designs. Engineers then use the results to feed internal analytical programs, which provide generator design specifications within minutes.

Delivering a fast, trusted workflow, ANSYS simulations significantly reduce research and development time while optimizing energy output. This enables INDAR to scale production and speed the path to market to further support the world's hydropower needs. 



ANSYS Maxwell simulation



ANSYS Maxwell simulation for apparent power using the new workflow

With production plants in Beasain & Segorbe (Spain), Milwaukee (U.S.A.) and Mexico D.F., INDAR, an Ingeteam company, delivers one-stop solutions for those sectors backed by strong R&D and engineering capabilities. By addressing the challenges that their customers face within different sectors, INDAR provides sustainable and efficient innovation. Its net sales totaled EUR 217 million with 800 employees. As of 2018, INDAR had 39 GW of installed power around the world.