Ansys

ADVANTAGE

EXCELLENCE IN ENGINEERING SIMULATION

ISSUE 1 / 2021

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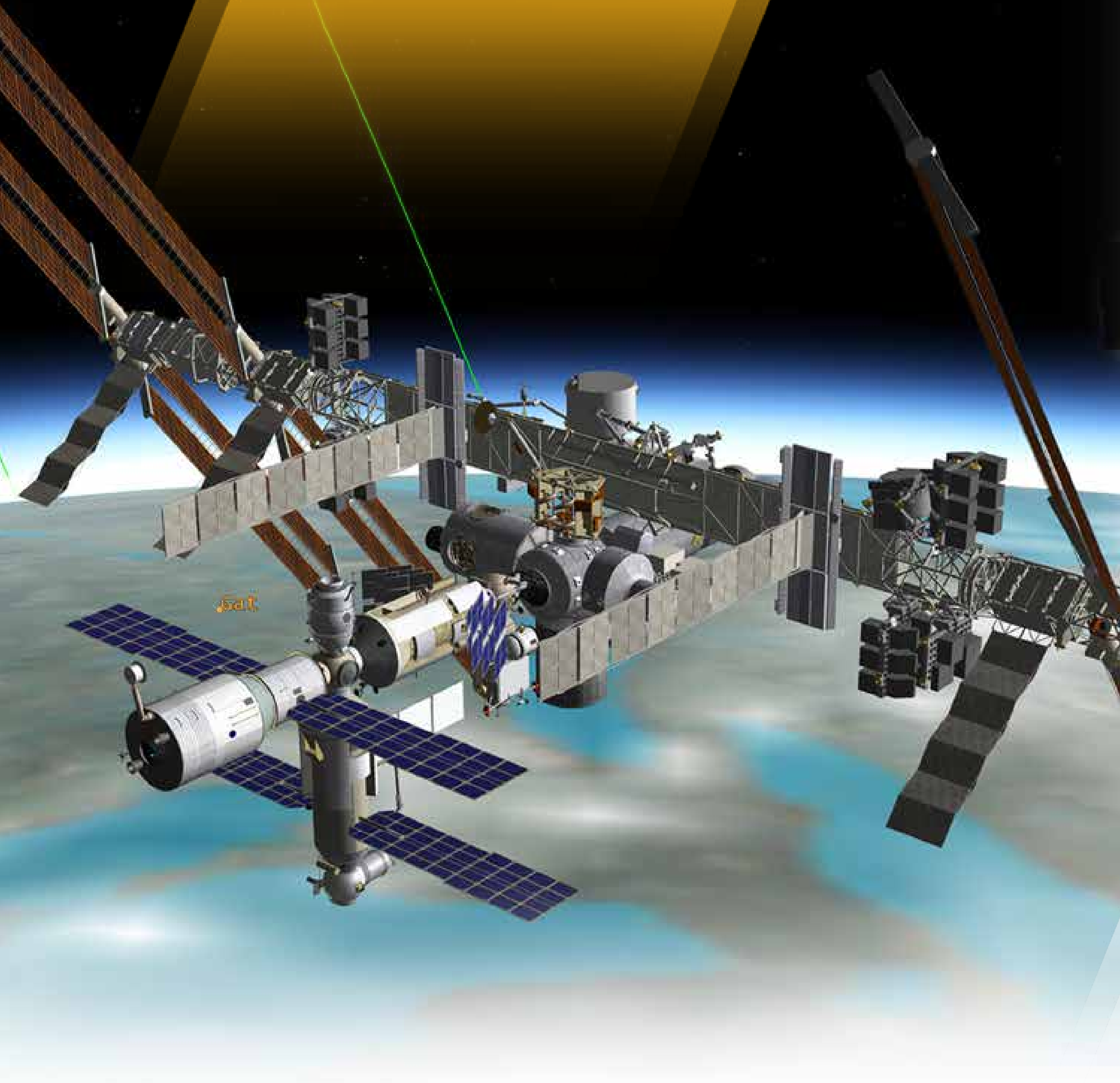
"Ansys' acquisition of AGI will help drive our strategy of making simulation pervasive from the smallest component now through a customer's entire mission."

– Ajei Gopal, President and CEO of Ansys



Ansys, AGI Extend the Digital Thread

Engineered products and systems can involve thousands of components, subsystems, systems and systems of systems that must work together intricately. Ansys software simulates all these pieces of the puzzle and their functional relationships to each other and, increasingly, to their environments.

Anthony Dawson
Vice President & General Manager, Ansys

The success of a mission can hinge on the functionality of one component. Consider the launch of a satellite; once in orbit, it cannot be recalled. For missions like these, there are no second chances. Simulation is critical throughout the entire systems engineering process to ensure that every component — whether part of the payload design, launch system, satellite deployment, space propulsion system, astrodynamics or onboard systems — will fulfill the mission. But how can you be sure of that if you don't also simulate the operational environment — that is, the mission itself?

Enter Analytical Graphics, Inc. (AGI) — the newest member of the Ansys family. AGI is the pioneer of digital mission engineering, which extends engineering simulation into the operational environment.

IN THE BEGINNING THERE WERE SATELLITES

When AGI was founded in 1989, its goal was to transform the world of satellite mission planning. Very quickly, however, AGI found that its customers wanted a simulation environment in which they could model assets in any domain — land, sea, air, space or cyber. As the capabilities of AGI's software grew, the company developed a new, powerful understanding of "the mission." Simply put, AGI defines a system's mission as the operational outcome that it is intended to achieve, and the environment in which it must achieve it.

AGI realized that, too often, systems aren't evaluated in the full context of their mission until physical prototypes are put into testing. Many organizations may not even realize the extent to which this approach squanders time and money, sometimes resulting in designs that can't cooperate with their interdependent assets or perform adequately in their operational environments. And this waste is avoidable with the right software approach — digital mission engineering.

ALL MISSIONS, GREAT AND SMALL

AGI's digital mission engineering software has been essential to many programs that you've seen in the news. Take for example NASA's OSIRIS-REx mission, which recently scooped up a mineral sample from the asteroid Bennu like a carousel rider catching a brass ring. AGI's flagship software application, Systems Tool Kit (STK), was used to calculate the delicate sequence of maneuvers that enabled the spacecraft to touch the surface of the asteroid without slamming into it. The STK scenario that produced the mission's nominal trajectory was also used to visualize the mission on its website.

While OSIRIS-REx is the most recent famous mission that AGI has supported, the company has a long history of making sure that important cargo gets where it needs to go. On Christmas Eve, it continued its 23-year tradition of working with the North American Aerospace Defense Command (NORAD) Operations Center on the annual Santa Tracker experience, which attracts more than 24 million visitors from across the globe each year. AGI uses STK to model Santa trackers that follow him on his trek around the world and capture video of his visits to famous destinations.

AGI
An Ansys Company

ADVANCING DIGITAL MISSION ENGINEERING

The pairing of Ansys and AGI will enable simulations with unrivaled depth of detail and breadth of scope. Customers who are already familiar with AGI's digital mission engineering software will find a wide array of digital design capabilities through Ansys, while customers who already design their products with Ansys software will discover the tremendous advantages of extending simulations beyond the point where the rubber meets the road.

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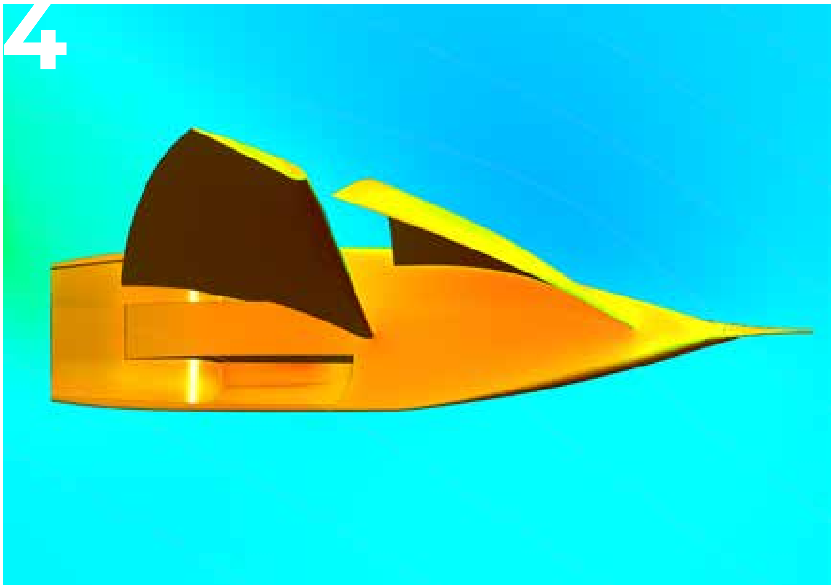

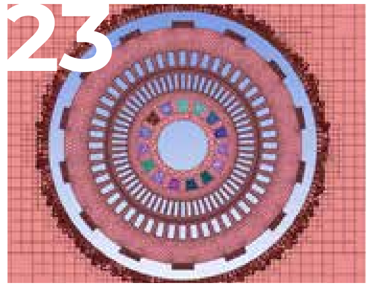

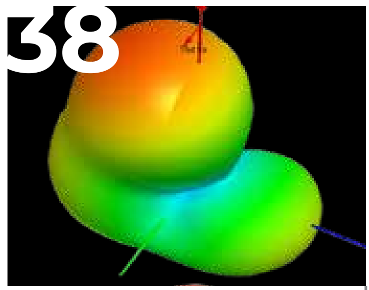

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If you've ever seen a rocket launch, flown on an airplane, driven a car, used a computer, touched a mobile device, crossed a bridge, or put on wearable technology, chances are you've used a product where Ansys software played a critical role in its creation.

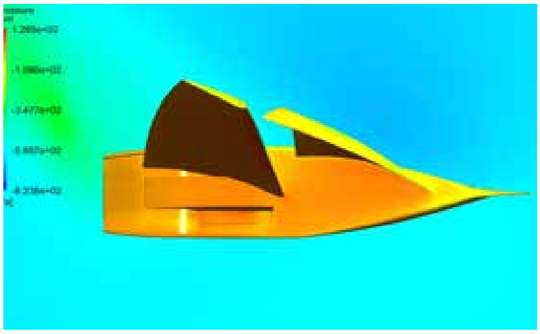
Ansys is the global leader in engineering simulation. We help the world's most innovative companies deliver radically better products to their customers. By offering the best and broadest portfolio of engineering simulation software, we help them solve the most complex design challenges and engineer products limited only by imagination.

Freedom of SPEED

Over the past quarter-century, America's Cup racing yachts have undergone sweeping shifts in their form and function to comply with evolving design rules. During that same period, Emirates Team New Zealand has pioneered and extended its use of Ansys simulation software in its design process to become a premier racing syndicate. To defend the Cup in 2021, the team is again relying on the combination of Ansys and in-house simulation tools for efficient assessment of large design spaces as it seeks to design a foiling monohull that balances speed and maneuverability.

By **Steve Collie**
Aerodynamics Coordinator
Emirates Team New Zealand
Auckland, New Zealand

For the first America's Cup, in 1851, the winning yacht was the schooner America, which defeated 14 other boats in a single race around the Isle of Wight in the U.K. that lasted more than 10 hours. America bested the British ships with a radical design for the time, validating technological advancements as a key to victory in the race. Over the next 132 years, fleet races gave way to match races, and the U.S. syndicate successfully defended 24 straight times before finally being defeated in 1983 by their challengers from Australia, who sailed with a technologically advanced winged-keel design. Since then, the last 10 America's Cup events have seen a challenging team victorious five times. Emirates Team New Zealand reclaimed the "Auld Mug" trophy in 2017 in Bermuda by defeating entrants from the U.K., Japan, France and Sweden before vanquishing the U.S. team in the final best-of-13 series.



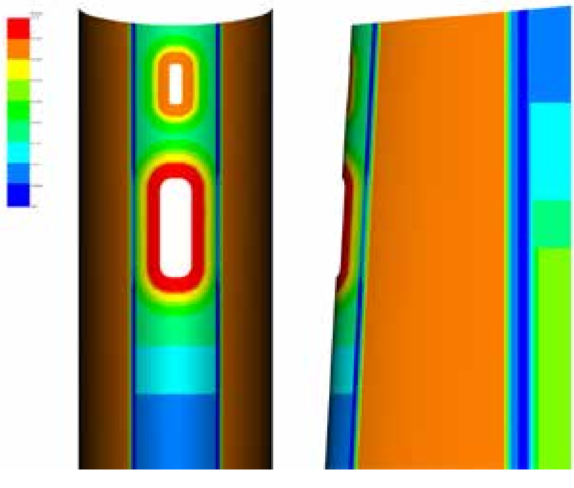
The performance of the boat at different points of sail is evaluated with the help of Ansys CFX.

Scheduled for March 2021, the 36th America's Cup will launch in Auckland's Waitematā Harbor as Emirates Team New Zealand sails as the Defender for the first time since 2003. The boat design rules have evolved greatly over the past three decades, from the International America's Cup Class (IACC) monohulls (1992–2007), to the wingsail catamarans (2010–2017), to the current AC75 class that features foiling monohulls and a return to soft sails. Throughout this period, Emirates Team New Zealand emerged as a consistent contender for the Cup — with consecutive victories in 1995 and 2000 — and has been at the vanguard of incorporating modeling and simulation tools into its design process.

AN EARLY DIFFERENTIATOR

In the late 1990s, the team used simulation, including Ansys Fluent for computational fluid dynamics (CFD) analysis, though mainly to supplement wind-tunnel testing and full-scale testing. A lot of the problems the designers tackled then were in evaluating different turbulence models and meshing strategies in an era when compute resources were a limiting factor. To determine whether design "A" was better than design "B," the design was first tested in a wind tunnel and then on the water. The team would spend weeks benchmarking one boat against the other, sailing for hours side by side. This repetition was required to get a significant result as conditions on one area of water could be very different from another area only a few hundred meters away.

The team discovered one advantage of using CFD was the 3D visualization of the simulation predictions for the movement of air and water over different hull and sail shapes. This helped Emirates Team New Zealand learn more about aerodynamics for sailing conditions that would be difficult to achieve in a wind tunnel. Any single, small design change may not have been responsible for the Emirates Team New Zealand victories, as the skill and experience of the crew are still paramount to adapt to the real-world conditions. However, when a few seconds is all the difference in winning vs. losing, the addition of simulation allowed the team to predict the cumulative effects of many small changes before building the final race boat. The designers acknowledged the need for simulation as being a vital component to winning the Cup.



ETNZ engineers use Ansys Composite PrepPost for modeling the detailed composite layup in various parts of the boat, such as the top of the mast shown here.

Downwind sails used to be developed with scaled models in a wind tunnel, but computational fluid dynamics has replaced wind tunnel and tow tank testing at ETNZ.

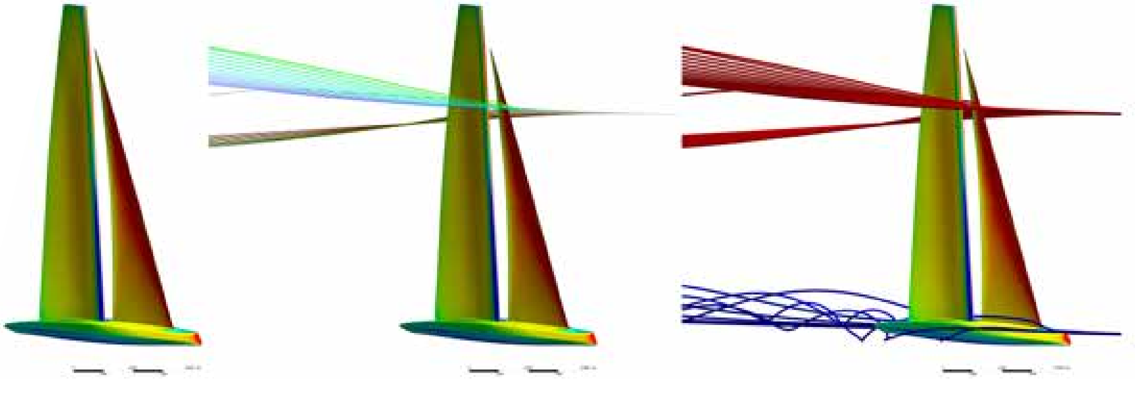
Credit: University of Auckland, Twisted Flow Wind Tunnel / Burns Fallow, 2002

WIDESPREAD ADOPTION AND NEW DESIGN RULES

As more racing syndicates added the power of simulation to their design arsenals, the Cup changed hands twice more over the next four events, and the 82-ft (25-m) IACC designs gave way to foiling multihulled craft with rigid wingsails. Design rules limiting wind tunnel testing and full-scale testing further increased the team's reliance on simulation; therefore, the team incorporated structural analysis software, including Ansys Mechanical and Ansys Composite PrepPost (ACP) into its modeling toolbox.

Where softsail monohulled crafts early in the IACC era were limited to an average speed of about 10 knots (11.5 mph), the combination of new hull concepts, lightweight materials and the wingsail over several Cup campaigns radically elevated race speeds to about 40 knots (46 mph). The multihulled catamarans could now essentially fly above the surface on a thin hydrofoil, known as a daggerboard, as the additional wind power transferred into much higher forward momentum. Races that once took hours in an IACC boat now would be completed in 30 minutes or less with a foiling craft. Previous engineering challenges to minimize wave-induced drag on the hull were replaced with designing structures to handle the massive forces generated by the wingsail and ensure that the sailors could control the crafts when foiling at such speeds. Specifically, the team needed a wing that could withstand large deformations in its ribs, spars and flaps. New courses set closer to the shore to be visible to large crowds of spectators required more sailing maneuvers, which further altered the design.

To achieve the balance of boat performance vs. controllability and maneuverability, Emirates Team New Zealand combined its large design space of Ansys structural and CFD models with its traditional velocity prediction program (VPP) into an in-house tool named Gomboc. Also known to the team as "the simulator," Gomboc enabled real-time simulation of different sailing conditions for each variation of the wing and hull design being studied. For more complicated calculations, it could pick results from an existing library or response surface. Ansys CFX was used to analyze boat and sail configurations in different conditions to determine the complete aerodynamic forces and moments.



Engineers look at surface pressures and air velocities with simulation to improve lift and reduce drag.

"The automation of the simulation process with Ansys software empowered the designers to accomplish in one week what once would have taken six months."

These conditions could include different angles of attack or different attitudes of the boat such as yaw, heel or pitch. From the aerodynamic results, the simulator could find the force and moment equilibrium and predict the speed.

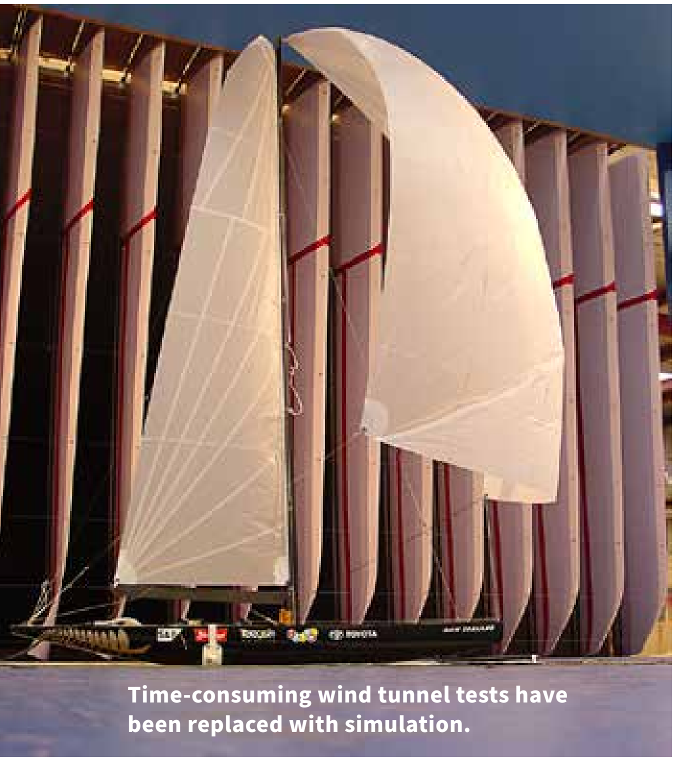
The simulator started off more like a video game played on a keyboard, though with its backbone in physics. Over time, the human interface included multiple screens, virtual reality headsets, and a lot of the same equipment that sailors use on the yacht — including steering wheels and control devices. Having the sailors get feedback from the simulator in real time turned into an efficient way of answering their questions, and of working out what questions to ask. This feedback gave the team confidence about what the performance would be for a given design before ever getting out on the water. They could then benchmark their own on-water performance against the simulator's predictions. Refined further by sensor data from experimental testing, Emirates Team New Zealand's experience of virtual sailing in the simulator helped to provide a needed edge against the competing syndicates. Emirates Team New Zealand overcame a close loss at the 2013 Cup finals in San Francisco to take a dominant victory in 2017 in Bermuda.

THE VICTOR KEEPS THE FOILS

After 10 years dominated by wingsails and multihulls, design rules were published in early 2018 for the 2021 Cup. The rules specify a monohull with soft sails, but with canted T-wing hydrofoils on both sides. Each team is limited to two full-sized 75-ft (23-m) boats, but may also build test craft up to 39 ft (12 m) long for additional on-water testing. The team only had a few months to design Boat 1, so fully relied on simulation to compare the performance of different foils, hulls and sail setups.

For the foil design, the rules require adherence to specific geometric and mass constraints. Emirates Team New Zealand and its competitors have been evaluating different foil shapes to accommodate a wide range of different speed conditions. For example, slender foils might work better at higher speeds but require adding ballast to conform to the mass rules. The foils have hydraulic and electronic control systems that power flaps analogous to airplane flaps to adjust vertical hydrodynamic force. Emirates Team New Zealand is using both Ansys CFX and Ansys Mechanical to model the complex relationship between the hydrodynamics and the structural mechanics involved in the foils and control systems.

Beyond the foil design, Emirates Team New Zealand is fully invested in analyzing almost every structural component of the boat. In the 2017 campaign, the designers used Mechanical primarily for coupled fluid-structure interaction (FSI) analysis of the wingsail with CFX. For the 2021 campaign, individual components are modeled with Mechanical, and there is also a global composite



Time-consuming wind tunnel tests have been replaced with simulation.

model of the hull and deck in ACP. These components must fulfill different strength or stiffness requirements based on rig loads, slamming loads and hydrodynamics loads, while still balancing between weight and performance.

With the return of soft sails and limited time for full-scale testing, the analysis of sail shapes is also a top concern. As sails are trimmable in a seemingly infinite number of ways, the designers have run more than 100,000 simulations of different sail shapes using CFX. Aerodynamic analysis of the hull is more important than ever because the hull will spend much of its time foiling, so the team also evaluated about 1,000 different hull geometries. By parameterizing the hulls and sails, they could efficiently generate very large design matrices that they could then use in the simulator.

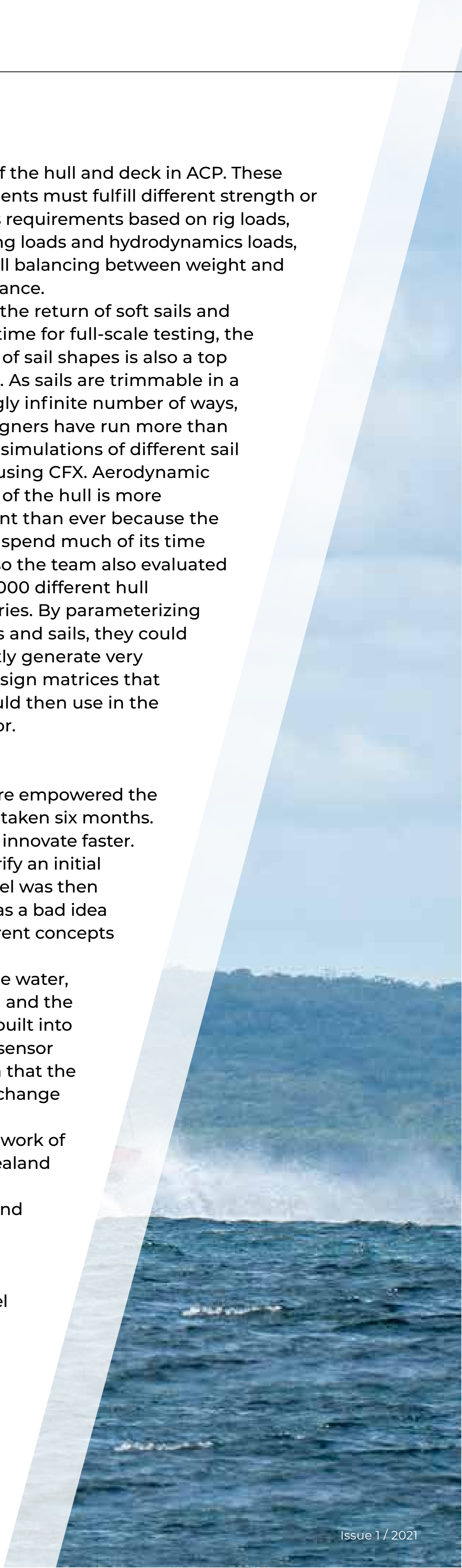
MANEUVERING TOWARD THE DEFENSE

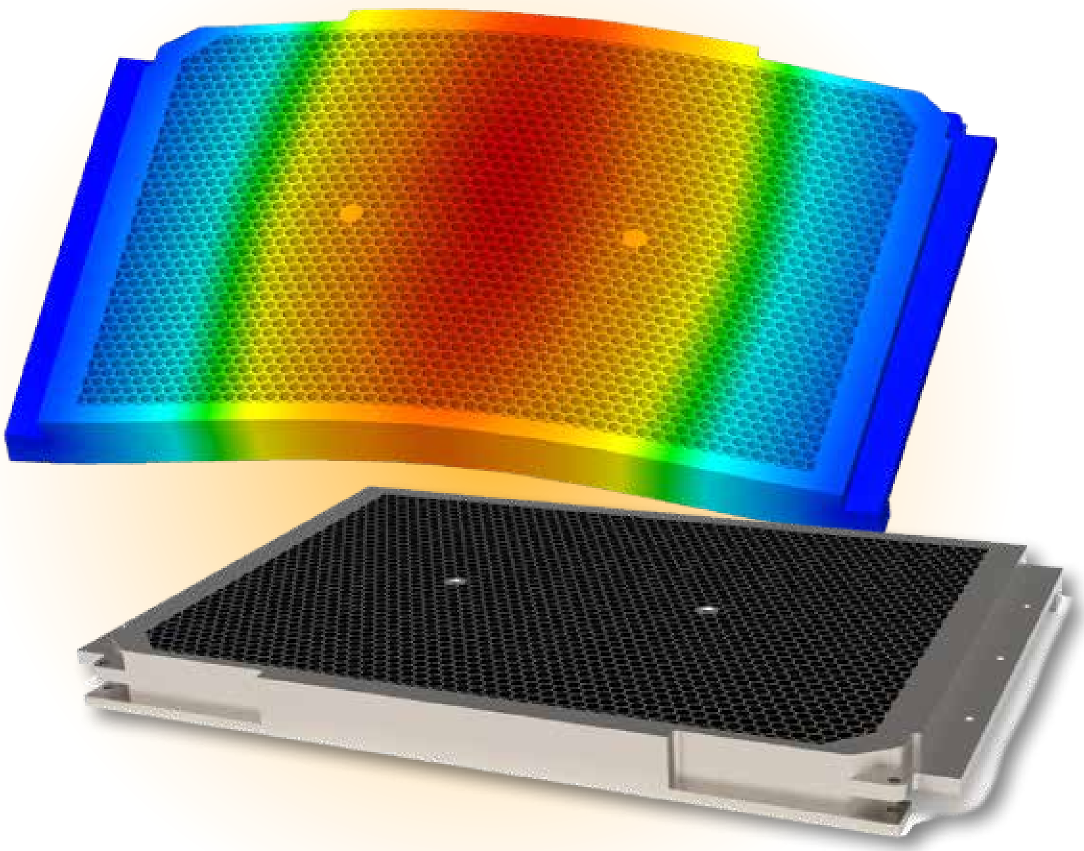
The automation of the simulation process with Ansys software empowered the designers to accomplish in one week what once would have taken six months. Ansys simulation software allowed the New Zealand team to innovate faster. For example, a simple structural model was often used to verify an initial concept that was based on past experience. The simple model was then refined to take more loading effects into account. No idea was a bad idea because simulation enabled the team to explore lots of different concepts and test them relatively cheaply.

As Emirates Team New Zealand validates its designs on the water, both Boat 1 (christened as *Te Aihe* — Maori for “The Dolphin”) and the team’s 12-m test boat (*Te Kahu* — “The Hawk”) have sensors built into the masts because mast bending affects the sail shape. The sensor data then provides information about the compressive strain that the sailors can use as they test loading and unloading the rig to change the sail shape to get more speed for given wind conditions.

The intelligence gathered from the modeling and testing work of *Te Aihe* and *Te Kahu* will be critical as Emirates Team New Zealand designs and builds Boat 2, which will be the team’s primary racing yacht. This comparison between the live monitoring and simulation of many design variations is giving the team the understanding, and ultimately the confidence, to push the boundaries needed to defend the Cup once again.

Emirates Team New Zealand is supported by Ansys Channel Partner LEAP Australia and composites design specialists from Ansys.





Aim Higher with Optimization

by **William Villers**, CEO and Chief Engineer, Arsenal Advanced Methods, Nashua, U.S.A.

HERE'S A SALES CHALLENGE FOR YOU: Try to offer a product to replace one that has been working well for decades in a conservative, risk-averse sector where the attitude is "If it's not broken, don't fix it." Your new product is lighter and dissipates heat more efficiently, which is essential to its operation, and uses less material in its construction. Still, the industry wasn't necessarily looking for a replacement. They are happy with the product they have now, and cost is not the main concern.

Arsenal Advanced Methods (Arsenal AM) is up against this challenge as they try to develop and market an innovative heat sink product to the DoD to keep electronic devices functioning optimally. These devices are responsible for radar image processing, radio communications, missile control, gun control and many other mission-critical operations. They have to be kept cool enough to function during military missions in harsh conditions where heat, vibration and shock can cause catastrophic failures.

Arsenal's founders had many ideas for various products in mind for years, but using the engineering simulation tools they had available would take weeks to evaluate a single design, and they would have to explore hundreds of design variants to accomplish their goal. So, they kept putting off the launch of their startup, waiting for computers to get fast enough to work with the tools they had. When they heard about Ansys Discovery, they knew it was the tool they needed, so there were no more delays. In 2018, they became part of the Ansys Startup Program — designed to support early-stage startups, now with over 1,000 members — and officially went into business.

An Arsenal AM honeycomb handle for aircraft components

AN IDEA BORN OF EXPERIENCE

After working in the aerospace and defense industry for 30 years, Arsenal's founders knew every component of an aircraft inside and out. They couldn't help but notice how certain parts could be made lighter by using less material. Like the numerous handles on electronic components that are just dead weight when the aircraft is operating — they only become useful when the plane is on the ground and a technician has to remove the component, then carry it to the maintenance station for inspection. Hauling this dead weight through the air costs fuel.

With their knowledge of topology optimization, Arsenal engineers realized they could design a lightweight version of these handles that would still do the job. They also knew that the components these handles are attached to are sometimes just machined aluminum plates, used as heat sinks to cool electronics onboard the plane, and switching to a 3D-printed honeycomb structure would save a great deal of weight, since there are up to 100 of these per airplane.

By saving a few pounds in each handle and heat sink, suddenly the payload is 100 pounds lighter. This translates into an extra 100 miles or 10 minutes of flight per mission, which could be the difference between success and failure. For space vehicles, the savings would be $10,000 per pound of payload. The return on investment is a great selling point.

An exploded view of the Arsenal AM honeycomb heat sink with TPG core

HONEYCOMB STRUCTURES ARE KEY

The difficulty in getting new products approved by the U.S. military is showing that they perform better than the existing equivalent. It can be a challenge when the equivalent part has worked for 30 years without fail. But military aircraft engineers are familiar with honeycomb structures because large parts of an aircraft are now made of composite materials formed of honeycombs to give them strength and stiffness.

For the lightweight heat sinks, Arsenal engineers had to optimize the number, size, pitch and wall thickness of the aluminum honeycombs to achieve the necessary strength and stiffness required for duty in harsh environments involving shock and vibration. They used Discovery to quickly explore these variations in honeycomb geometry, with the help of Ansys SpaceClaim direct geometry manipulation of CAD surfaces, which allowed them to add smaller features to facilitate metal 3D printing. The optimal values determined by simulation for these honeycomb parameters varies by application, but in general they can reduce the mass by 40%.

While honeycombs reduce the amount of aluminum used compared to a solid block, their open spaces also reduce the thermal conductivity of the heat sink, which is detrimental to its operation. The air in the open spaces acts as an insulator rather than a conductor of heat. Experimental tests showed an unacceptable buildup of heat in certain regions of the honeycomb, so Arsenal engineers began looking for a solution. After exploring many materials for their thermal properties, they found that filling the honeycomb holes with graphite, an excellent heat conductor, made their heat sinks even better at removing heat than the solid-plate originals. The final design is a 3D-printed aluminum honeycomb filled with graphite, which still reduces the mass by 20% compared to the original solid aluminum plate structure.

Other flight applications have varying degrees of vibration during operations, so different honeycomb designs are needed to achieve the optimal stiffness. Unmanned aerial vehicles (UAVs) experience more vibration at different levels than a standard aircraft, for instance. A large gun onboard a military aircraft produces vibration and shock when it fires, and all electronic components onboard must be able to withstand these forces. So, each application needs a customized honeycomb design solution to meet operating requirements.

EXPLORING DIRECTIONAL LOADS

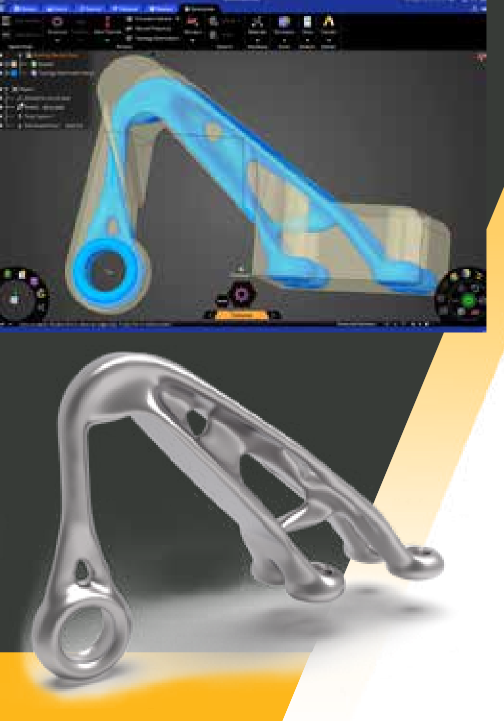
Another way of lightweighting a component is to use simulation to determine in which direction the load is being applied during an application. When you know how the load is being distributed, you can react to it, bend it and move it around the way you want. By reinforcing the component in that direction and removing material from other areas that bear no load, Arsenal engineers can reduce even more unnecessary payload weight.

Directional solutions can also be deployed to reduce vibrations. Using Discovery showed Arsenal engineers that they could build components that are rigid in one direction, yet flexible in another to damp out vibrations. Additive manufacturing made it possible to build these structures.

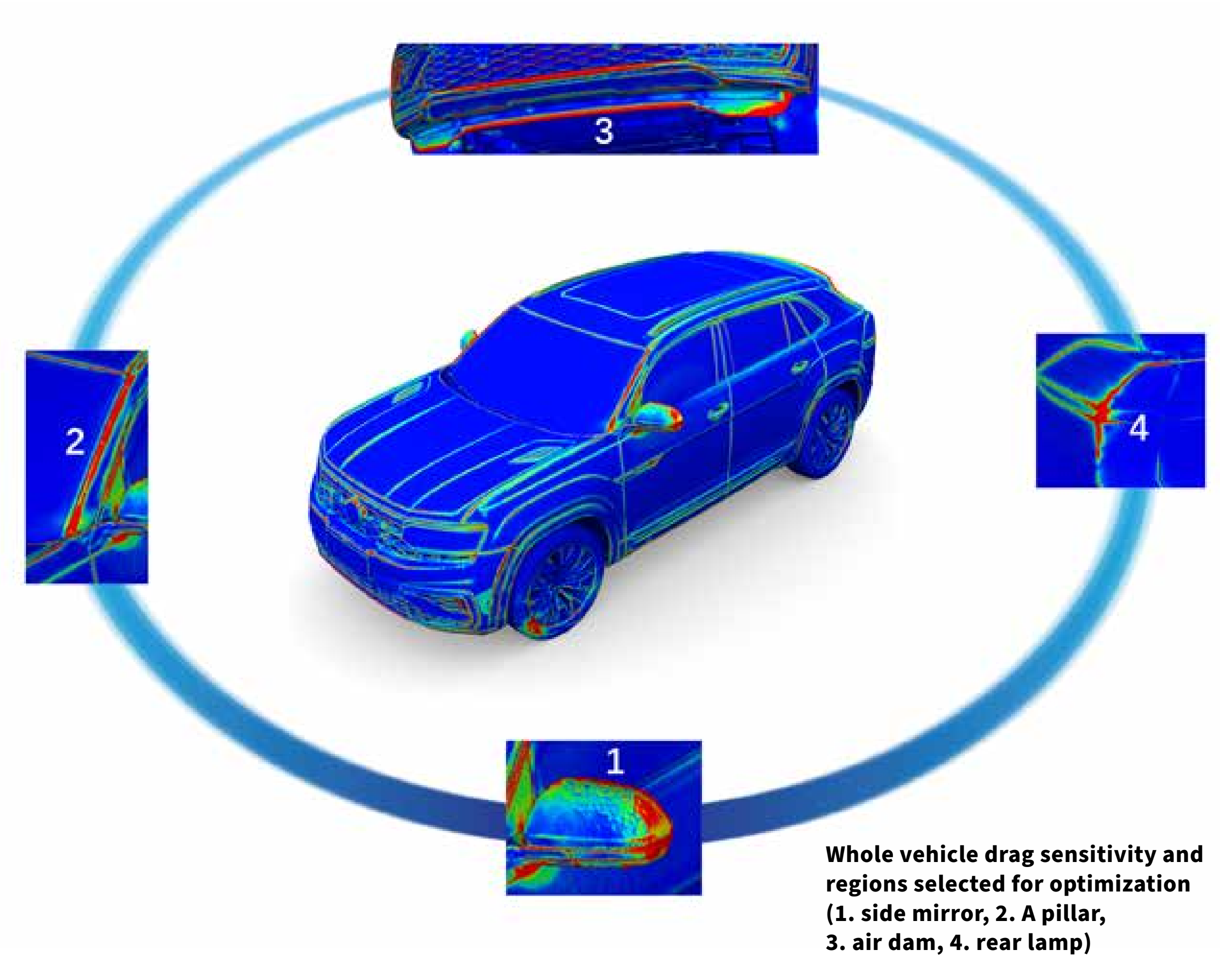
Arsenal's prototype products have started to get some notice at conferences, so they are gradually overcoming the reticence to switch to a new solution that is built into the conservative military electronics sector. They plan to attend Air Force and Space Force pitching days where they can present their ideas to these governmental agencies to try to secure more funding for their startup. If successful, some of these funds will go into acquiring more Ansys simulation solutions so they can keep innovating quickly and inexpensively as new ideas arise.

BEYOND HONEYCOMBS INTO ORGANIC SHAPES

Like most startups, Arsenal AM is looking into various opportunities to use their engineering expertise to solve other aircraft challenges. Aircraft have a huge amount of electronics that could be modified for lightweighting purposes, including some of the support structures that hold the electronic components in place. In another project, they have designed a lightweight hinge bracket for an aircraft door using topological optimization. Investigations into adding microchannels to heat sinks to enhance the cooling properties are ongoing. They have even done consulting work involving new designs for jet engine blades.



A hinge bracket for an aircraft door, with blue showing the reduced mass of the topologically optimized version vs. the original design (top, in beige), enabled the creation of the hinge bracket via additive manufacturing. >



Whole vehicle drag sensitivity and regions selected for optimization (1. side mirror, 2. A pillar, 3. air dam, 4. rear lamp)

Reducing Drag for a Better World

By **Ren Chao**, Program Leader, Product Engineering/Predevelopment
SAIC Volkswagen, Shanghai, China

Car designers work hard to improve gas mileage and battery capacity, but not all improvements come from tuned up engines and bigger batteries. Body refinements designed to reduce drag can also help. Engineers at SAIC Volkswagen in Shanghai are using Ansys Fluent Adjoint Solver to refine vehicle designs faster and more efficiently.

When it comes to automobile driving range, more is always better. Whether you are driving a car with a traditional internal combustion engine or one with a completely electric power source, the further you can go on a tank of gas or a full battery charge, the better — on your wallet as well as on the environment. Automobile companies around the world know this and design accordingly.

One path leading to better mileage with lower greenhouse gas emission targets mechanical solutions — more efficient engines and subcomponents, for example. While it may be possible to eke more efficiency out of an internal combustion engine, the fundamental technologies in play are a century old and fairly well refined. Efficiencies here are possible, but harder to achieve. Better battery designs for electric cars may be able to deliver much greater efficiencies in that space, but, again, improvements there may depend on mechanical and chemical breakthroughs that are harder to achieve.

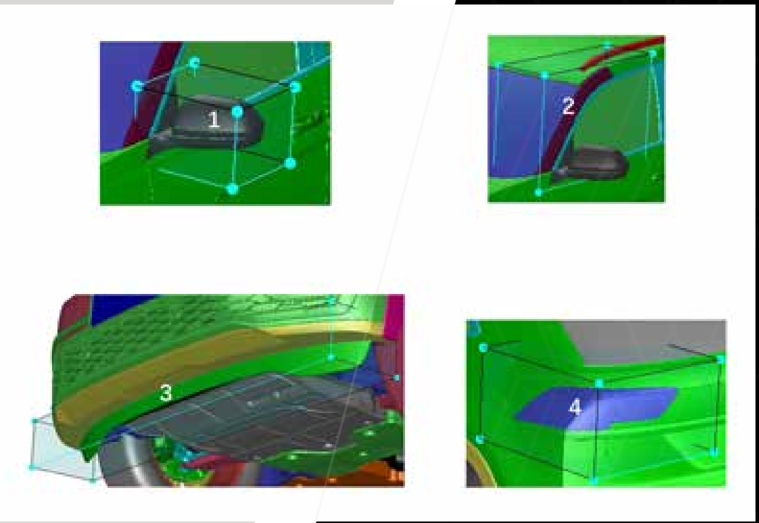
"If we could optimize airflow around the vehicle and reduce drag through subtle refinements in design, we could improve driving range and fuel efficiency."

A different path to better mileage performance — one gaining traction as a result of the adoption of the Worldwide Harmonized Light Vehicle Test Procedure (WLTP) — lies in reducing the drag of the vehicle. If subtle refinements in design could optimize airflow around the vehicle, driving range and fuel efficiency could improve without depending entirely on chemical and mechanical breakthroughs.

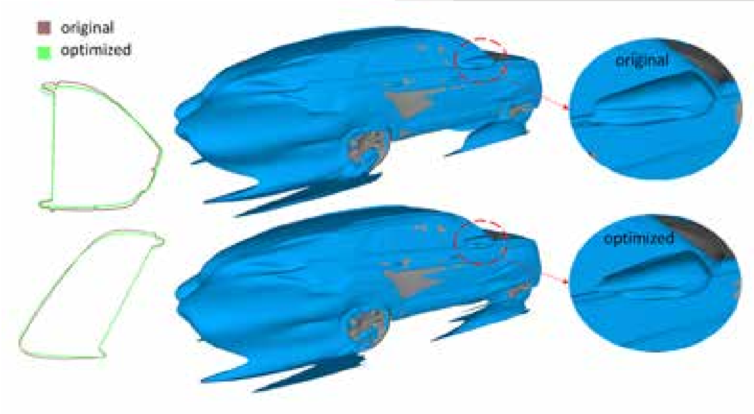
That's exactly what SAIC Volkswagen has been doing with the help of Ansys Fluent Adjoint Solver.

ADJOINT SIMULATION ISN'T NEW, IT'S JUST NEW TO AUTOMOTIVE

Using computer simulations to refine autobody design isn't new, but other simulation methods have distinct limits. Approaches such as parametric simulation, design of experiments (DOE) and others are valuable, but they are highly compute-intensive and can take a long time to produce results. In a DOE approach, for example, every combination of parametric variables is simulated one by one until all possible combinations have been exhausted. If you're working with more than a few variables, the number of calculations can become huge, and it can take days to complete all the simulations and determine which combination achieves the desired outcome. It's also worth noting that you, as the engineer designing the simulations, need to understand how the component you're modeling works and define the relevant parameters — which means there are optimization opportunities you may miss because you did not parameterize properly.



Morphing boxes selected for analysis in Ansys Fluent Adjoint Solver



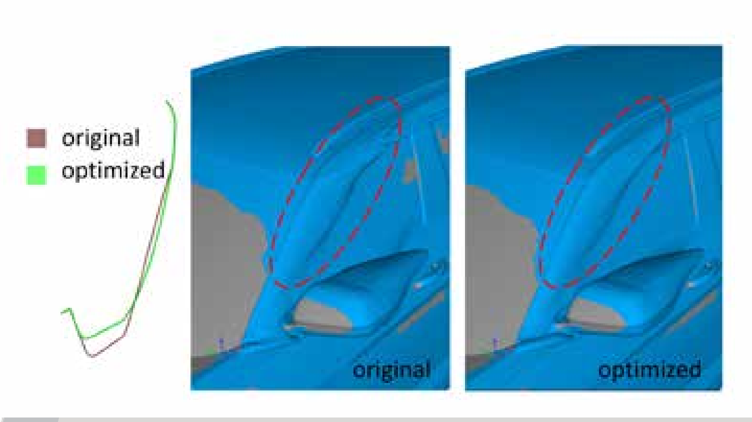
The mesh morphing results and the simulated flow field. The outlines at the top of the figure show mirror shape from the side and top, respectively.

The adjoint method of simulation started in the world of aeronautics in the 1970s and only found its way into automotive manufacturing simulations more recently. It turns out to be a far more efficient way to solve challenges involving shapes and drag reduction. Setting up adjoint simulations does not require you to define parameters in the way you would using the DOE method, for example. You define specific goals, and the adjoint method modifies the mesh itself to achieve the stated goal within specified manufacturing constraints. In contrast to the DOE approach, the adjoint approach involves free-form shape optimization that requires very few simulations to achieve an optimized design. It also works by morphing the existing mesh, so it is not necessary to recreate mesh for different designs. As a consequence, the computational resources and time required to arrive at an optimized result are usually orders of magnitude lower than in other approaches.

GETTING MORE MILEAGE FROM SIMULATION TOOLS

A case in point: SAIC Volkswagen recently used Ansys Fluent Adjoint Solver to explore ways to reduce drag on an existing production Volkswagen SUV. Engineers used Fluent to gain insight into areas of particular drag sensitivity, then focused on finding ways to reduce drag in several specific areas.

One of the targets included the side mirrors on the SUV. SAIC Volkswagen engineers generated surface mesh from ANSA (their preprocess software) then imported that into Fluent meshing to generate volume mesh. They then ran simulations using Ansys Fluent Adjoint Solver to optimize the body of the mirror so as to achieve the lowest drag coefficient (Cd). Using a multi-node compute cluster with 512 cores and 64 GB of memory, the Fluent simulation took between three and four hours and provided clear insights into the design alterations that could yield the lowest Cd. In contrast, had this same simulation been attempted on a similar cluster using the DOE approach, it would likely have taken two to three days to complete the simulation.



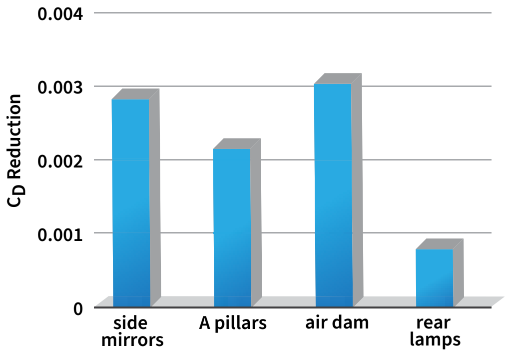
Comparing original vs. optimized A Pillar contours in Ansys Fluent Adjoint Solver

The ability to run optimization simulations in hours rather than days has important ramifications. Within the design schedule, there is only so much time to make recommendations on changes that can improve the aerodynamics of an automobile. If engineers can use Ansys Fluent Adjoint Solver to solve an optimization challenge in a matter of hours rather than days, they can perform a far greater number of simulations in the time allotted to look for solutions. That opens up a wide range of possibilities. If a designer doesn't like the aesthetics that the changes would involve, they might incorporate other design changes with aesthetics they *do* like — and, in the time gained by using the adjoint simulation methods, another set of drag optimization simulations could be run on the new design to see how that performs.

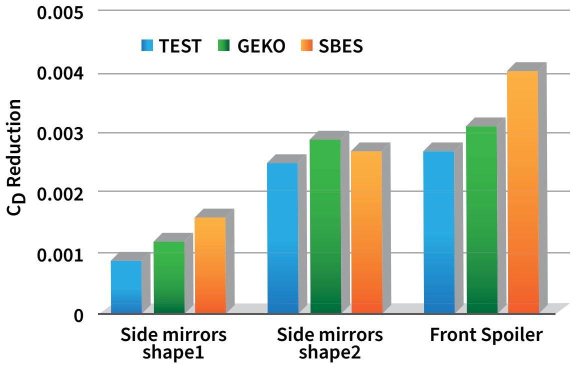
Alternatively, the time might be used to look for other areas where drag could be reduced for greater efficiency. In addition to analyzing the mirrors for drag optimization, SAIC Volkswagen engineers used Ansys Fluent Adjoint Solver to analyze the air dam on the SUV, the front windshield pillars and the taillight subassembly. Not only did Ansys Fluent Adjoint Solver perform all these analyses within the window of time allocated for input but the tool enabled engineers to identify opportunities for measurable drag reductions in all areas.

NOT JUST HOT AIR

Altogether, the opportunities for optimization identified by Ansys Fluent Adjoint Solver could provide a clear boost in helping to improve the fuel efficiency of an SUV by reducing drag. SAIC Volkswagen engineers used Fluent along with the latest Generalized K-Omega (GEKO) model for steady state calculation and a high-accuracy transient Stress-Blended Eddy Simulation (SBES) model for verification, so engineering felt confident that the solutions suggested by Fluent were optimal within the conditions created by those models. Overall, the optimizations suggested by Fluent Adjoint Solver predicted a 10X reduction in Cd in the steady flow simulation and an 8X reduction in the transient flow simulation.



Drag reduction after optimization



Comparing wind tunnel (test) results to Fluent simulated results

Still, the accuracy of these findings had to be validated, and that called for outfitting a full-sized vehicle with optimized versions of the components and then taking it for a spin in the Shanghai Automotive Wind Tunnel Center (SAWTC) in Tongji University. The trip to the wind tunnel quickly showed good compliance between the Cd reductions projected by Fluent Adjoint Solver and those measured in the wind tunnel itself.

BUILDING A BETTER FUTURE

Will good compliance between Ansys Fluent Adjoint Solver and the real-world results obtained in the SAWTC eliminate the need to put cars through costly wind tunnel tests? Not entirely. The wind tunnel test provides the final word, but knowing that there is good compliance between Fluent and the real world gives engineers confidence that the Fluent Adjoint Solver's results are going to be on target. The time gained by using an adjoint approach to simulation can be used to run more simulations, on more elements of a vehicle, in the same amount of time that previously was necessary to run only a few simulations.

Ultimately, the result is a better automobile, more efficient use of resources, lower emissions and longer range. That's not just good for SAIC Volkswagen. It's good for everyone.

Additive Manufacturing Hinges on Optimization

By Ansys Advantage Staff

Hyundai Motor Group's analysis team and the design for additive manufacturing (DfAM) lab of TAE SUNG S&E (TSNE) recently developed an automotive hood hinge with Ansys Additive solutions. TSNE is an Ansys Elite Channel Partner in Korea. The optimized hinge weighed 13% less and was 5X stiffer than the previous hinge. The design won the grand prize at the annual Korea Additive Manufacturing User Group (KAMUG) DfAM Competition, which celebrates 3D printing and manufacturing convergence cases and commercialization. The team used Ansys Additive Prep to design the hood hinge with topology optimization and Ansys Additive Print to predict recoater crash, crack and deformation problems. They built a metal hood hinge after verifying and checking the external shape and internal overhang area via computed tomography (CT) scans.

We caught up with Jun Cheol Lee, manager of the Advanced Manufacturing Computer-Aided Engineering Team at Hyundai Motor Group, to learn more about the topology optimization process for the hood hinge.

The as-built part

Ansys Advantage: ***What motivated you to participate in this competition?***
Jun Cheol Lee: I think it was a very relevant chance to augment our capacity in additive manufacturing. All procedures — making out a plan, learning about additive manufacturing simulation and building real parts using additive machinery — are great experiences for us.

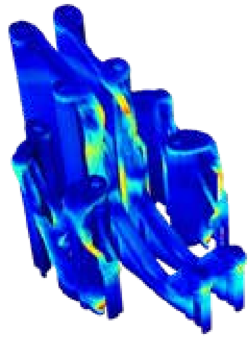
AA: ***What are the benefits of topology optimization and additive manufacturing?***
Lee: Topology optimization basically provides a solution that increases the stiffness while reducing the weight of the product. The important point is that it is very difficult to increase the stiffness when using the existing shape as it is. By making the optimization area as large as possible, it is possible to increase the rigidity in the process of leaving only the really necessary areas and removing other areas. As a result, we can deviate from the traditional shape design. We can make any shape of a part with the right performance. Lightweighting and performance improvements can coexist.

AA: ***Can you take me through the process of creating the new hood hinge design, step by step? How did you redefine the design domain?***
Lee: A traditional hinge bracket has a single support. It is good for mass production, but very weak for Y-axis direction forces. So we choose double support brackets to improve Y-direction deformation.

AA: ***What are the considerations of going from stereolithography (STL) to computer-aided design (CAD)?***
Lee: This is a very important part. Sometimes, we must convert the model for use in CAD tools. Ansys provides a very easy and open conversion solution.

AA: ***How did you ensure the optimal means to additively manufacture the part (orientation, supports, deformation prediction, build quality/ porosity)?***
Lee: In this case, we did not make many choices about orientation. The length of the hinge almost fits the limit of the machine-made height, and there is a certain amount of pressure, so all the parts must be separated by an hour. Therefore, we applied improved supports so that there is less deformation.

Orientation support



Additive manufacturing process simulation

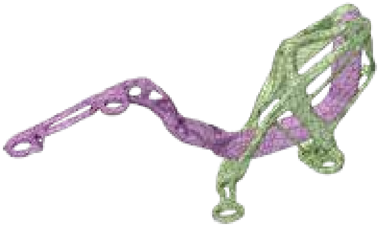
AA: ***How was Ansys Additive Prep and Print helpful in the process?***
Lee: Additive Prep is an innovative tool for pre-additive simulation. It makes it possible to achieve proper part orientation and reasonable support. After the phase optimization was completed, the layout and support design proceeded using Additive Prep. An orientation map was used for the arrangement, and the degree of deformation was set to be small to make it easier to remove the support. When using the orientation map, we can predict supports, build time and degree of deformation. If the user sets conditions, the layout automatically changes according to the conditions, saving a lot of time.

After completing the deployment, we used Additive Prep to create supports. The supports were designed in such a way that verification could be performed with Additive Print. If they required modification, we verified them again to confirm the optimal design. Process analysis can be performed with Additive Print to obtain a solution that can prevent recoater crash, and predict cracks and deformation that may occur during the build.

After checking all the variables, we can minimize the number of failures and ensure the quality and build via the actual 3D printing equipment. Ansys Additive Prep and Additive Print are essential programs for additive manufacturing.

AA: ***Do you have plans to continue to use Ansys Additive in the future that you can discuss?***
Lee: Yes. This time we made only part of a vehicle. Next time we will expand to look at production. There are so many things to optimize in the factory. Of course, we will work together with Ansys.

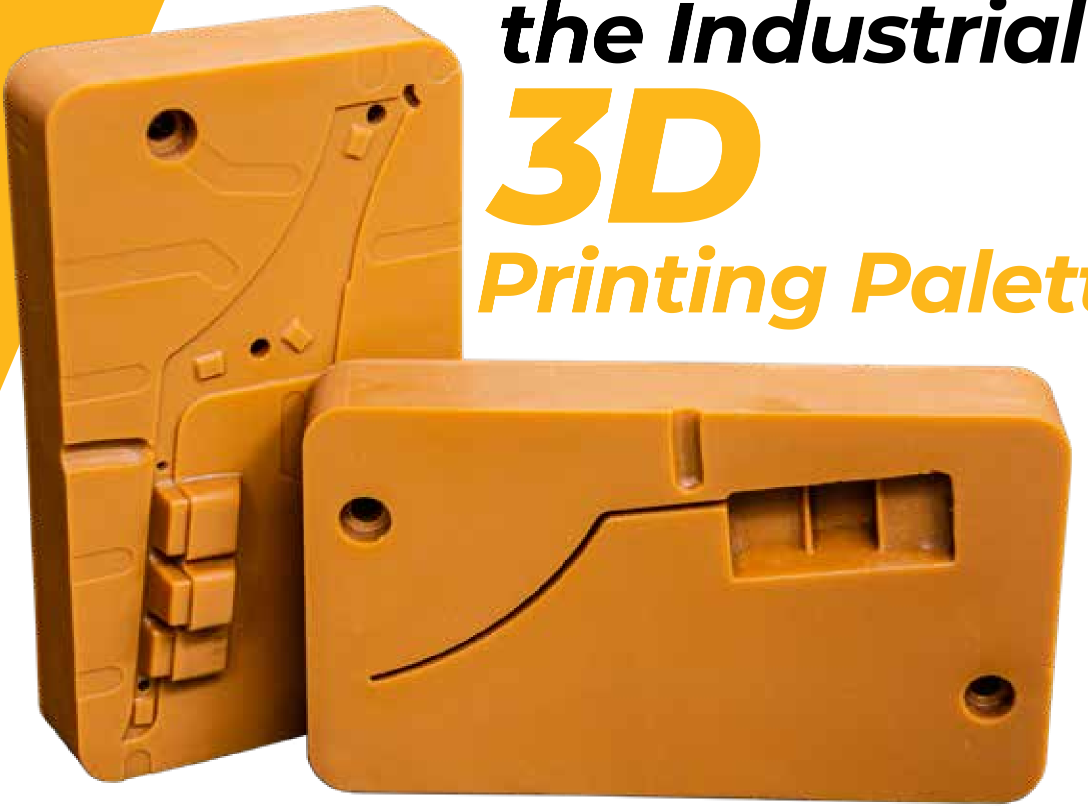
Topology optimization



Reverse engineering

Virtual validation

Composites Expand the Industrial 3D Printing Palette



A mold 3D-printed by the FLUX ONE

By Ansys Advantage Staff

Nearly 40 years after a Japanese researcher named Hideo Kodama created a rudimentary 3D printer by running photopolymers through a rapid prototyping system, the worldwide market for 3D printing products and services is enormous — estimated to be between $40 billion and $51 billion.[1] And there seems to be only blue skies ahead, with a compound annual growth rate of approximately 26%.[2]

Given the gee-whiz nature of 3D printing — it's been used to construct everything from a human bladder (a project of Wake Forest University's Institute for Regenerative Medicine) to a working watercraft (a 2.2-ton boat printed at the University of Maine's Advanced Structures and Composites Center) — it's tempting to think that every advance that could be made has been.

But, as demand has accelerated, the tasks assigned to 3D printers have become increasingly difficult, such as building parts that have challenging geometries. Customers are also asking for more complex printing materials, including fiber-reinforced resins that are stronger, more durable and more functional than the ordinary thermoset polymers the industry grew up with. That means there's room for new printing technology that performs better, faster and more affordably.

To expand the capabilities of composite printing for industrial applications and allow customers to leverage materials that were once inconceivable, or at least impractical, the engineers at Fortify developed the FLUX ONE 3D printer.

The FLUX ONE 3D printer automates the composite material build process by combining proven fiber reinforcement strategies with high-resolution digital light processing (DLP) printing. The printer's features include continuous mixing of ceramic fibers and other functional additives that reinforce the photopolymer, and magnetic alignment of fiber strands for strength and stiffness.

Fortify engineers used Ansys Maxwell (part of the Ansys Electronics desktop), Ansys Fluent and Ansys Mechanical simulation software to streamline overall product design, reduce time to market, optimize the printer's magnetic field, manage heat exchange and reduce power consumption.

PROCESSES IMPROVE PRODUCT CONSISTENCY AND STRENGTH

One of the areas Fortify is focusing on is industrial injection mold tooling. Whether the mold is intended for prototyping or low-volume production, the requirements for printing the tooling are the same: accuracy, high-detail resolution, industry-standard surface finishing and high-temperature resistance.

Traditional 3D printers often struggle to provide those must-haves. Functional additives can settle to the bottom of the printer during the build process, causing unequal distribution from top to bottom and diminishing the quality of the tooling. In addition, getting the millions of microfibers aligned just right — a criterion for strength and durability during the injection process — has been difficult to achieve.

The FLUX ONE 3D printer overcomes both problems. Its patented Continuous Kinetic Mixing (CKM) process ensures consistent material properties with a broad range of composite material suspensions. The printer is also equipped with Fluxprint, an alignment module with multiple large magnetic coils; by coating the fibers with a magnetic material and then applying a magnetic field across the build area, the FLUX ONE 3D printer can selectively align the fibers to strengthen the piece, reduce the risk of wear or breakage in vulnerable areas, and improve thermal or electrical properties.

SIMULATION ENABLES MAGNETIC FIELD OPTIMIZATION

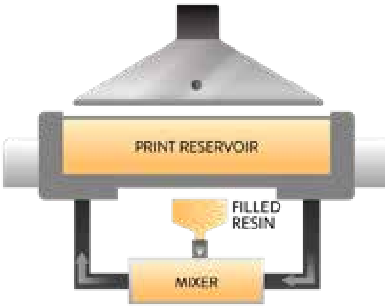
The challenge of creating a magnetic field that can be quickly tuned in any direction while optimizing magnetic flux density (that is, the magnitude of the magnetic field) is no easy feat, especially when engineers have to keep the printer's power requirements and operating costs in check.

With Ansys Maxwell electromagnetic field simulation, Fortify engineers modeled a number of fundamentally different magnetic designs. By running simulations of the electromagnetic coils in tandem, the team could analyze the tolerance of the field direction in different areas of the build and determine how much power would be required to create each field.

Particularly useful was Maxwell's probing tool, which enabled Fortify engineers to quickly and easily iterate designs, apply boundary conditions and run models at different currents and measure outcomes at different points of the build area. This simplified a complex problem to a few important output parameters, including the electrical efficiency of the magnetic field.

Maxwell simulations also helped them understand the relationship between the power required to generate the magnetic field and exchange heat through the fluid cooling system (which was designed in Fluent), and control the inductance of the magnet — that is, its tendency to oppose any change in the electric current running through it. Ultimately, this enabled Fortify to optimize magnet performance and response while removing heat and maintaining a reasonable power requirement.

Fortify used Ansys Mechanical as part of engineering due diligence as well, simulating the mechanical response to forces during the printing process.



Continuous Kinetic Mixing (CKM) blends resin with additives.

PRINTER DELIVERS NEXT-GENERATION PERFORMANCE

Ultimately, Fortify engineers modeled dozens of design iterations before prototyping the FLUX ONE 3D printer. They would not have been able to arrive at the magnetic design without rapid iteration in finite element analysis; in other words, Ansys simulation enabled a solution that would not have been found otherwise, one that represents a previously unimaginable step change in 3D printing material performance for injection mold tooling and other applications.

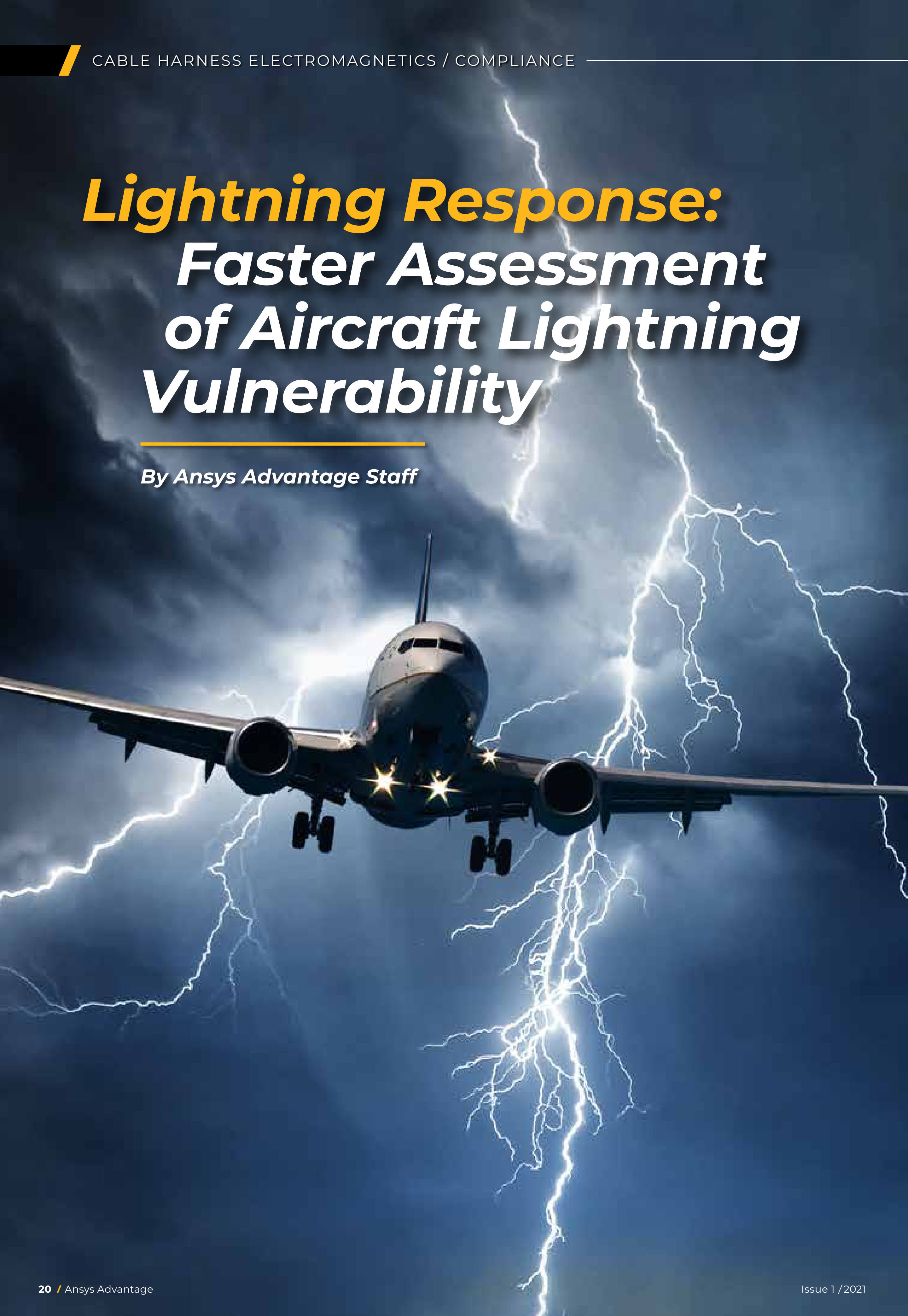
Sources

1. *"3D Printing Market Worth $51.77 Billion at 25.8% CAGR," Fortune Business Insights*
2. *"Global 3D printing products and services market size from 2020 to 2024," Statistica*

By coating composite fibers in a magnetic material, the FLUX ONE 3D printer can selectively align the fibers to strengthen the part.

Lightning Response: *Faster Assessment of Aircraft Lightning Vulnerability*

By Ansys Advantage Staff

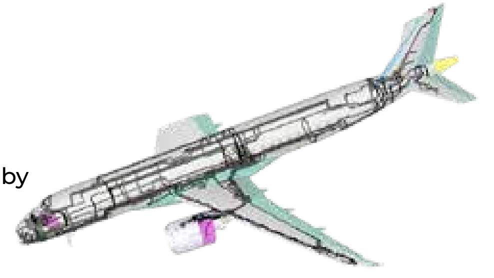


Data from a Brazilian aerospace company indicates that for every 10,000 hours a short-haul regional aircraft flies, it will sustain at least one lightning strike.

For those with a fear of flying, that might be one time too many. But the fact is, while passengers could see a flash or hear a loud noise, chances are the flight will continue safely to its destination. Fortunately, there hasn't been a catastrophic aircraft event caused by lightning since 1988.[1]

That's not to say that transport category aircraft are somehow immune to the impact of lightning strikes, or that the good track record is merely the result of luck. Aviation authorities require manufacturers to engineer lightning protection into every aircraft component and system, then demonstrate they've complied with rules and regulations. To assess vulnerability to lightning strikes, aviation engineers have to understand the specific lightning environment for the aircraft. Traditionally, that has depended on performing physical lightning tests, a costly and often cumbersome process.

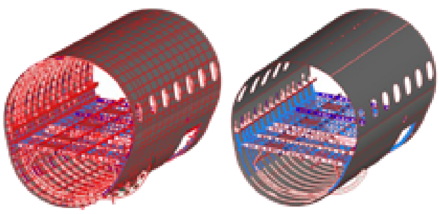
A manufacturer of civilian and military aircraft used Ansys EMA3D Cable with integrated MHARNESS solver to improve their understanding of aircraft system lightning response and validate a numerical approach to compliance that compared full aircraft simulations to full physical lightning transient analysis (LTA) tests.



Full aircraft simulations were compared to full aircraft LTA tests to validate a numerical approach.

A NEW APPROACH FOR CERTIFICATION

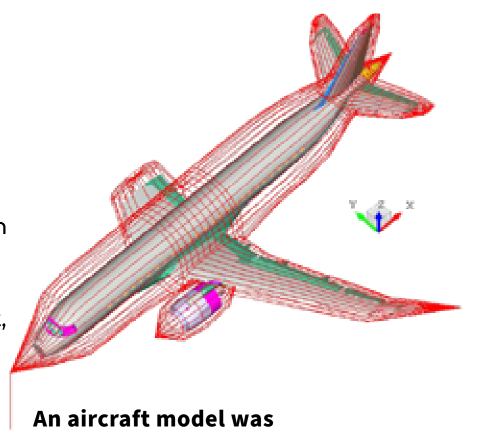
When lightning hits an aircraft, it can produce direct or indirect effects. Direct effects include physical damage to structures and components; indirect effects occur when lightning induces transients into electronics cables, causing a power surge that can disrupt or physically damage flight-critical electronics systems. Although the vast majority of incidents cause only small problems that can easily be repaired, lightning strikes are nothing commercial aircraft manufacturers, regulators or the flying public want to leave to chance. That's why aviation authorities worldwide have developed strict lightning protection criteria.



Fuselage section of original model (left) vs. the computational electromagnetics simulation model, showing component simplification

As part of certifying an aircraft's response to lightning, manufacturers traditionally submit results from physical lightning tests, which are done on the tarmac by generating lightning-like energy and injecting it into a test flight vehicle. The process is expensive and complex, requiring special equipment, additional personnel and, often, enough time to reconfigure the aircraft to place the lightning-generating probes in exactly the right spots. Altogether, conducting the test can ground a test plane for as long as a month, gridlocking the schedule if there are other certification tests to be done on the same flight vehicle. What's more, physical lightning tests can damage the aircraft, resulting in additional delays for repair.

Simulation avoids these types of bottlenecks, but for every simulation effort, the ability of the model to accurately reproduce experimental results must be determined and demonstrated.



An aircraft model was initially prepared for in-flight configuration. Adjustments were made to the in-flight model to match the test configuration.

As part of the development of a prototype transport category aircraft, the aircraft manufacturer used Ansys EMA3D Cable with integrated MHARNESS, a cable harness electromagnetic solver, to model lightning's indirect effects on avionic electronics. They then compared the results against traditional full aircraft LTA tests. These techniques measure the temporary oscillation that occurs in the system because of a sudden change in voltage and currents, and are used in physical testing to establish equipment transient design levels (ETDLs) and aircraft actual transient levels (ATLs) — the amplitudes and waveforms that the systems and equipment must withstand for functionality and safety. The simulation and full vehicle test results closely matched, validating the approach of using computational electromagnetics (CEM) simulation software to determine aircraft ATLs in a manner similar to traditional full vehicle LTA analysis.

UNPARALLELED DETAIL AND ACCURACY

To analyze how lightning couples with the electronics harness — in other words, how lightning finds its way into the collection of cables and wires that runs from the cockpit through the body of the aircraft — the manufacturer first had to recreate a model based on the actual aircraft design. Ansys EMA3D Cable with MHARNESS provided a workflow that allowed engineers to model cable packing in the harness as well as the actual routing and spatial positioning of each cable and wire throughout the entire aircraft. No other simulation software could have replicated the test vehicle configuration with the same level of detail and accuracy as EMA3D Cable did.

Other steps included:

- Determining structural material properties.
- Determining cable properties to understand transfer impedance, a measure of their shielding performance.
- Simulating lightning levels on cables.
- Validating the simulation model.
- Reducing the amplitude of the waveforms to meet the DO-160 lightning protection standard. Waveforms represent how voltage and current change over time. Reducing the amplitude of the waveforms can lessen equipment malfunctions.

Engineers initially prepared the model for inflight configuration but later refined it to match the experimental test configuration.

LIGHTNING SPEED COMPARED TO TRADITIONAL TESTING

The manufacturer achieved a variety of benefits from using simulation to determine lightning response in its new aircraft, including:

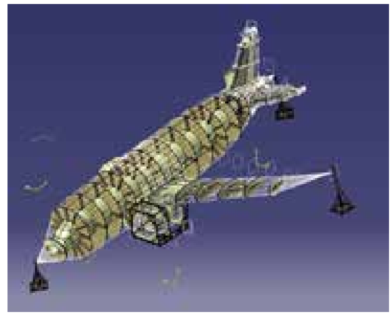
- Reducing the scope of expensive aircraft testing.
- Improving test setup and configuration.
- Expanding probe points beyond what is available for physical testing without reconfiguring the aircraft.
- Eliminating the need to reconfigure or modify flight test vehicle components.
- Optimizing cable routing.
- Eliminating test generator noise issues, data acquisition limits and probe implementation effects.

Simulation also reduced the testing period from as much as a month to a fraction of the time, and made it quick and easy to change the design after testing was complete.

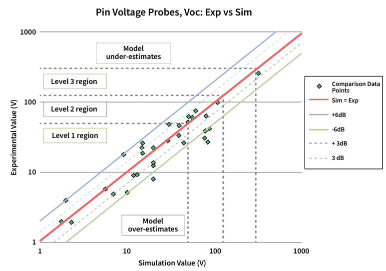
Perhaps most important, Ansys solver technology enabled the company to achieve simulation results that were comparable to LTA measurements. Amplitudes were on the same order of magnitude, and waveforms had similar peaks and duration. Being able to produce these results provides confidence in the modeling technique and the parameter inputs and suggests that the simulation approach of predicting lightning transients could be accepted for aircraft certification.

Source

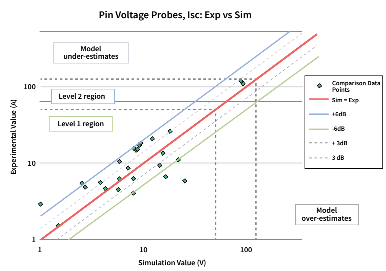
1. "7 Aircraft Disasters Caused by Lightning Strikes," 24/7 Wall St., LLC, Feb. 21, 2019



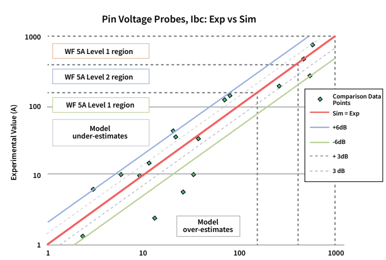
Return conductor system developed for full vehicle testing that excludes the right-hand wing and horizontal stabilizer because of symmetry



Scatter plot comparisons for pin voltage measurements, VOC



Scatter plot comparisons for short circuit current measurements, ISC



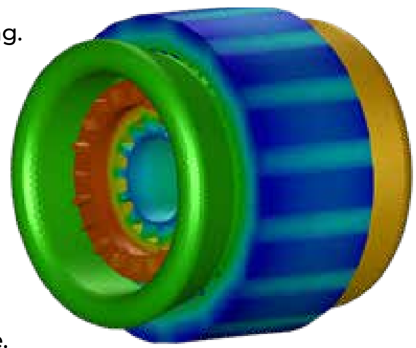
Scatter plot comparisons for bundle current measurements, IBC

Fast Tracking Next-Gen Electric Traction Motors

By **Eng. Luca Boscaglia**, Ph.D. Candidate – Electrical Motors Designer for Vehicle Applications, Chalmers University of Technology, Gothenburg, Sweden

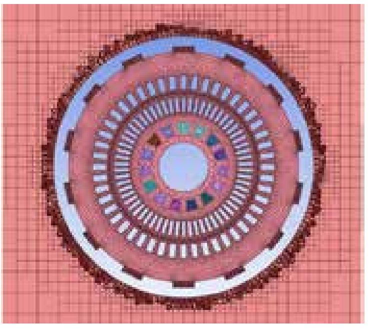
When you hear the train coming down the track, traction motors are driving those wheels. Rail systems engineers have been tasked with creating an enhanced, high-powered electrical traction motor with torque density, which will help trains run more efficiently, consume less fuel, produce fewer emissions and reduce overall energy consumption.

To accomplish this, motor thermal performance must be improved. But this isn't easy because metropolitan trains typically only have a small, confined environment to house a motor. As a result, motors are becoming increasingly compact and are required to produce more power in the same volume, leaving less space for cooling. Additionally, motors must be able to provide the specified power without overheating critical components and decreasing the operational efficiency. Not having an established methodology for assessing the motor's thermal performance early in the design phase presented an obstacle that ABB engineers needed to overcome.

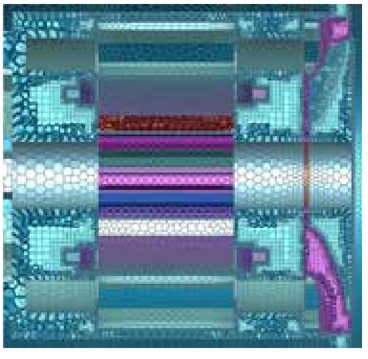


Temperature distribution on stator, windings and rotor computed by CFD

For this, a team composed of ABB, Ansys and Politecnico di Torino turned to Ansys Fluent,



Cross-sectional view along the axial direction of the CFD mesh



Cross-sectional view along the radial direction of the CFD mesh

which delivered tremendous modeling accuracy and enabled engineers to assess hotspots across critical components, including the end windings, stator slots and rotor bars. However, engineers needed a faster way to compute the thermal BTU. By coupling Fluent with Ansys Twin Builder's dynamic reduced-order modeling (ROM), they could rapidly and accurately analyze the thermal behavior of electric traction motors along their full duty cycles.

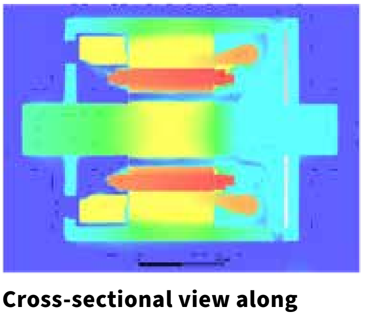
A ROM gave the team a way to obtain thermal performance results extraordinarily fast. This empowered ABB engineers to examine a motor model, select random operational parameters and quickly demonstrate the behavior of a traction model in response. Normally, with a traditional solver, this would require many hours or even days. Using a dynamic ROM, engineers accomplished this task in just a few milliseconds.

CREATING THE DESIGN IN FLUENT

After Ansys SpaceClaim was used to clean up the computer-aided design (CAD) geometry and extract the fleet volumes to prepare the model, ABB engineers imported it into Fluent to measure the thermal distribution across both fluid volumes and solid parts in steady state. Here, a single conjugate heat transfer (CHT) analysis helped engineers accurately predict thermal performances by leveraging both CFD and heat transfer models in less than 10 minutes with simulation. This helped Politecnico di Torino analysts explore several different design conditions in terms of boundary conditions and operating conditions, build their reference model and run several design configurations.

Usually the pre-processing phase is the most demanding stage of a CHT analysis, requiring engineers to check the quality of the mesh elements. Instead, Fluent Mosaic meshing did most of that heavy lifting while keeping elements to a minimum to drive fast, accurate results.

To make the reference models run faster, ABB leveraged high-performance computing (HPC). Simulating the full duty cycle — the full transient simulation — across more than 32 cores required 17 days to generate traditional models with 99% accuracy. HPC proved invaluable for generating this machine learning training data, which engineers used to build the ROM.



Cross-sectional view along the radial direction of the temperature distribution computed by CFD

BUILDING THE ROM IN ANSYS TWIN BUILDER

The ROM is a simplified, compressed version of a reference model that reduces the time required to optimize and simulate a complex system while preserving the essential accuracy. Exploring design alternatives 10 to 100 times faster than a reference model with similar accuracy, the ROM enabled high-confidence prediction of motor thermal behavior in duty cycles with a high number of operating points.

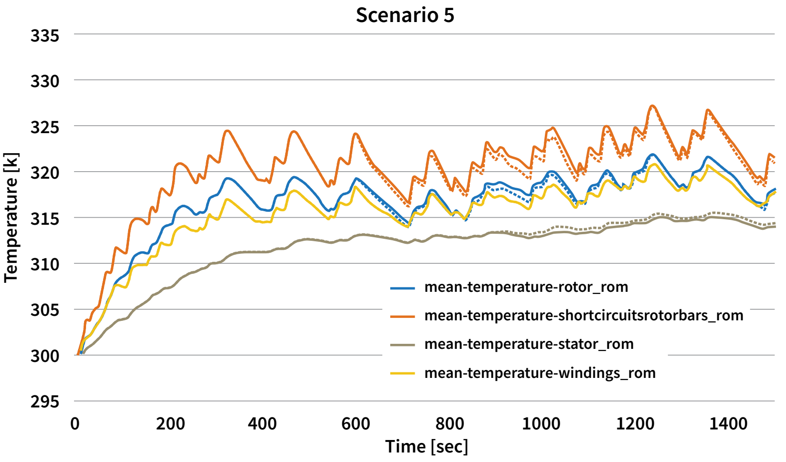
After engineers properly designed, manufactured and deployed the physical prototype of the electric motor, they put it to the test with the ROM. They ran the simulation model of the motor in parallel and in real time against the prototype as it ran down the track. This would not have been possible with a traditional solver, which takes hours to run at a minimum. Instead, the ROM ran the simulation in milliseconds, so engineers could predict any motor failures and improve operations in real time.

A dynamic ROM was primarily created for the transient simulation because engineers needed to capture the thermal response of the electric motor to predict motor thermal behavior during a full duty cycle with a high number of operating conditions that change over time.

Running a dynamic ROM was key for engineers to understand the motor's behavior as it provided different levels of power dissipation in response to thermal inertia and various transient effects during a typical duty cycle. For example, consider a subway train that begins moving from its first stop. First, there's an acceleration phase, followed by a cruise phase and then a braking phase to reach the next scheduled stop. During these phases, the temperatures of several motor components change continuously and differently, and this process repeats for 10 to 20 stops along the track as the subway crosses a city. When the train parks, the motor stops, and its varying thermal load must be cooled down.

Ultimately, the dynamic ROM provided insight into countless operational scenarios a train might encounter, ranging from traversing up and down hills to managing the slickness of a wet track.

After an extensive optimization of the model, the main engineers were able to the run the ROM in mere milliseconds, saving themselves tremendous amounts of time, without trading speed for accuracy. In fact, the deviation of the ROM in estimating the motor thermal performance was less than 1 C from the full order reference model.



CFD vs. ROM comparison for the transient thermal responses

VERIFYING THE DESIGN

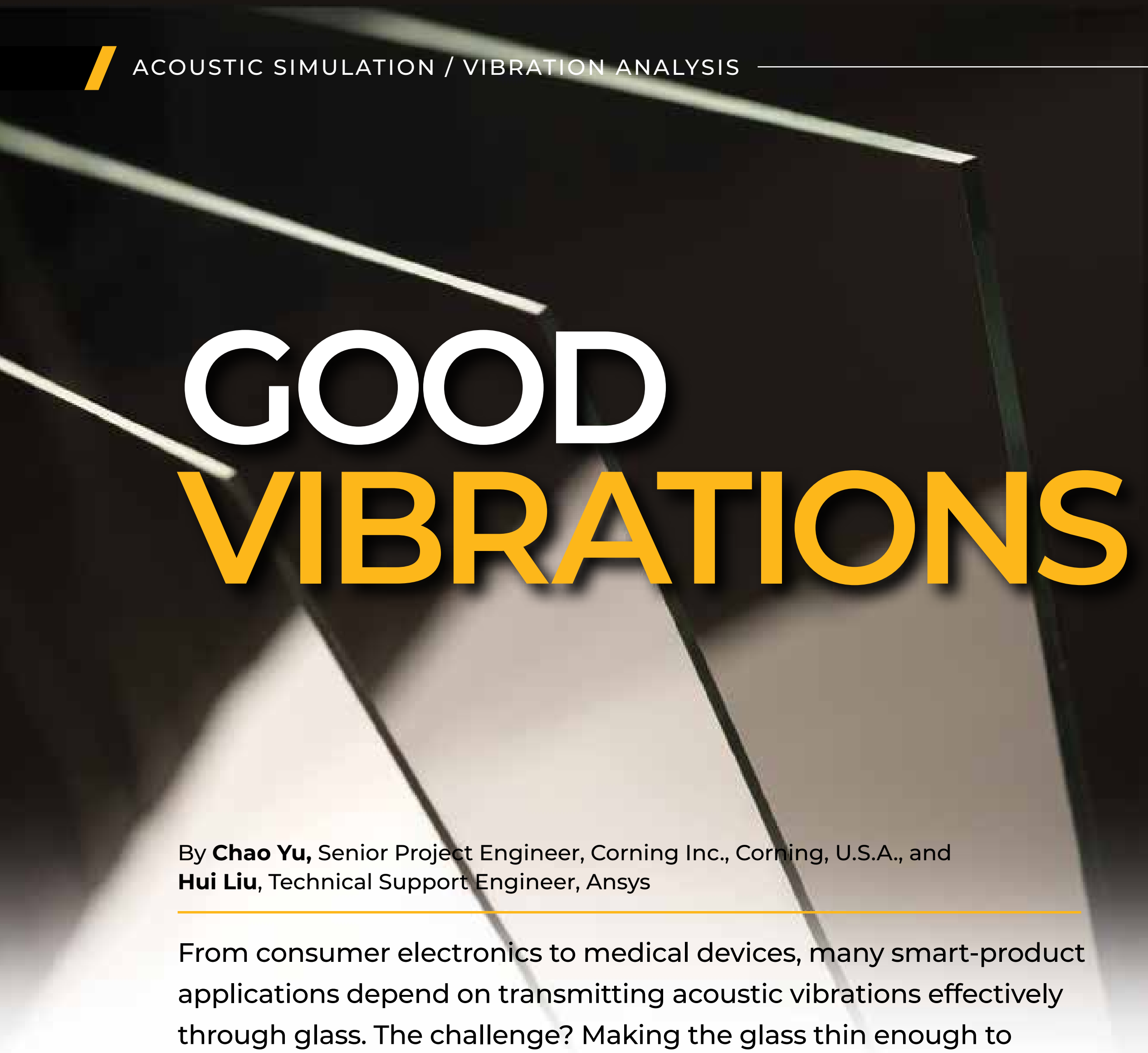
Next, ABB engineers conducted experimental temperature measurements to compare the full CHT results with the data received from the prototype motor's thermocouple sensors. ABB found that the deviation between the mass flow rate of the coolant (air) measured from the experimental results and model was within a 5% margin of error, demonstrating the accuracy of the CFD analysis. ABB engineers also proved that the temperatures in steady state measured in the experimental setup matched up well with those in the Ansys model.

Once the prototype motor and the ROM were completed, engineers ran the two against each other. As the prototype motor raced down the track, engineers compared it with its ROM counterpart. Because the thermal model of the prototype was tested and validations were carried out for both CFD and heat transfer, demonstrating an error of the model within the 5% range, ABB engineers now have a template model procedure they can use to optimize the thermal design of future motors.

This data was used to create a model to forecast the thermal behavior of future machines during the design stage. As a result, the development team can radically reduce the number of physical prototypes built, reducing computational time from days and weeks to seconds.

CITATION

This article references research conducted by L. Boscaglia, F. Bonsanto, A. Boglietti, S. Nategh and C. Scema: "Conjugate Heat Transfer and CFD Modeling of Self-ventilated Traction Motors," 2019 IEEE Energy Conversion Congress and Exposition (ECCE), Baltimore, Md., USA, 2019, pp. 3103-3109, doi: 10.1109/ECCE.2019.8913138

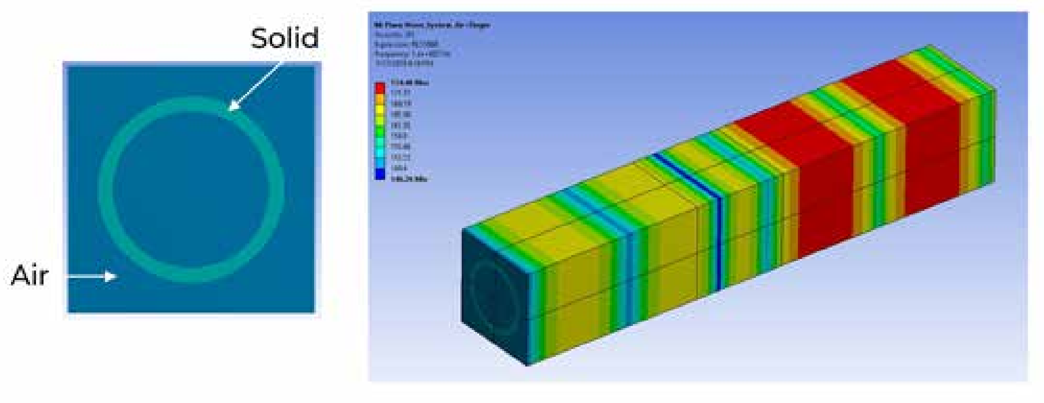


GOOD VIBRATIONS

By **Chao Yu,** Senior Project Engineer, Corning Inc., Corning, U.S.A., and
Hui Liu, Technical Support Engineer, Ansys

From consumer electronics to medical devices, many smart-product applications depend on transmitting acoustic vibrations effectively through glass. The challenge? Making the glass thin enough to accurately transmit ultrasound waves, yet structurally strong enough to withstand daily use. Corning engineers rely on multiple Ansys solutions to balance acoustic and mechanical performance as they develop smart, innovative glass solutions.

With Consideration of Both Finger and Air Loads



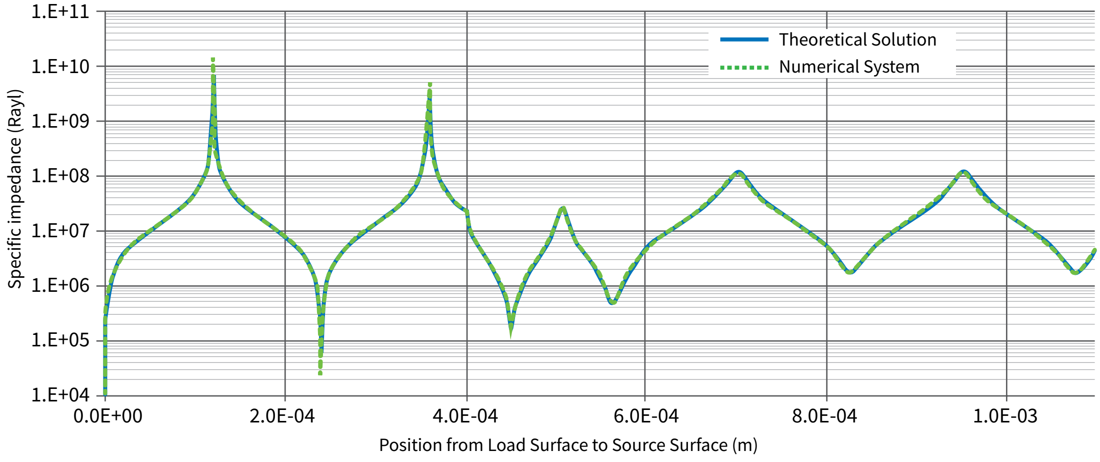
One consumer application involved the placement of a ring-based load on the glass surface, with the load distributed across the glass in a non-uniform pattern. Ansys software easily enabled the required simulation and analysis.

ALREADY A CENTRAL COMPONENT OF MANY CONSUMER PRODUCTS — from cars and planes to residential windows — glass plays a critical role in many of today's smart products. Consumer electronics often feature displays and touchscreens that not only relay information but also serve as user controls. Medical devices frequently rely on glass to display, communicate and guide the results of advanced imaging procedures.

While smart-product applications are diverse, many rely on the ability of glass to accurately transmit acoustic ultrasound waves from one side of the glass — the user or "control" side — to the other side, where a receiver gathers and processes the signal.

In these applications, the glass substrate must be thin enough to accurately transmit ultrasound vibrations, thick enough to withstand daily use and structurally strong enough to withstand unexpected impacts. In addition, to keep up with consumer demand, it usually must be as lightweight as possible.

The engineering team at Corning is challenged daily to balance these competing requirements as it develops advanced glass solutions for smart-product applications. Engineers must deliver proven, accurate solutions, but they must do so quickly to meet customers' ambitious launch targets.



Corning engineers have successfully validated the Ansys model with theoretical solutions. Excellent agreement was obtained on acoustic-specific impedance across all layers.

BUILDING ON A SOUND RECORD OF SUCCESS

For decades, Corning engineers have relied on simulation solutions from Ansys to meet these types of complex product design challenges. For example, the Corning development team has helped automotive customers significantly reduce glazing weight while maintaining acoustic noise levels inside cars by developing new technical glasses, based on Ansys-enabled aerodynamic and vibro-acoustic analysis (see "A Window into Automotive Noise," *Ansys Advantage* V12 I1).

To solve the problem of effectively sending ultrasound waves through glass, the team applies Ansys Mechanical to assess acoustic loading, vibration, structural strength, deformation and a range of other mechanical aspects of glass performance.

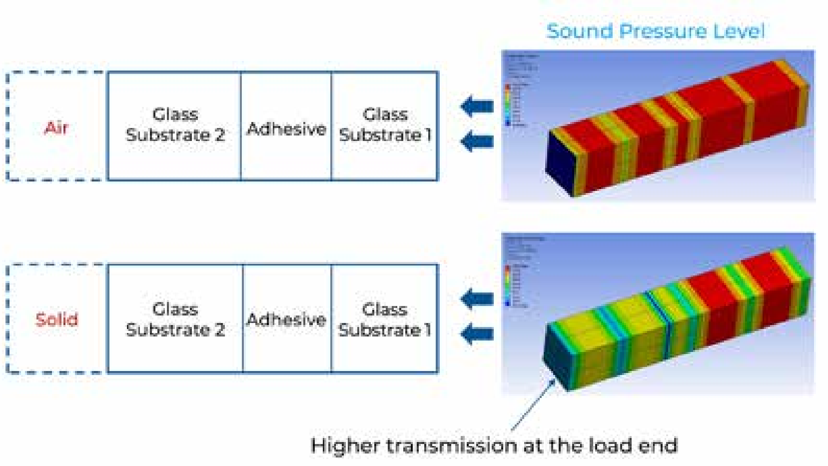
To ensure that these simulations are conducted quickly and are integrated with other product development processes, the team uses Ansys Mechanical Acoustic. This solution enables Corning to develop customized, unified simulation workflows that integrate all Ansys technologies and other engineering tools. The result is clearer and more accurate trade-offs, faster and better decisions, and enhanced employee productivity.

MINIMIZING ACOUSTIC IMPEDANCE: A CASE IN POINT

Recently, the product development team at Corning used the combination of Ansys Mechanical and Ansys Mechanical Acoustic to model and assess a new glass configuration for a customer-specific application. The glass structure was composed of an adhesive layer, sandwiched between two glass substrates. Corning engineers needed to simulate and predict how well the configuration would transmit acoustic ultrasound waves, with minimal loss.

This required the team to study the acoustic impedance of the new glass structure, or the resistance of the glass stack to transmitting ultrasound waves. For the specific customer application,

Comparison of Sound Propagation with Different Loads



To replicate actual operating conditions for the final product, Corning engineers applied acoustic loads from both air and solid materials. As they examined the degree of impedance generated by different loads, the product development team was able to ensure accurate transmission and high acoustic quality in real-world use cases.

any sound transmission loss would be disastrous, interfering with the end product's core functionality. The engineers needed to evaluate both characteristic impedance (the intrinsic resistance of the material, across its entire surface) and specific impedance (a measure of the material's resistance at certain critical points on its surface). Both types of analysis were needed to optimize performance.

To determine impedance, a numerical model was constructed in Ansys Mechanical Acoustic; the model included a plane wave source with an exact ultrasonic frequency between 10 and 20 MHz, as well as the isotropic materials stack. The adhesive was treated as a solid; its elastic properties were considered during the impedance calculations.

To address any limitations or weaknesses in individual product layers, both component- and system-level models were developed in Ansys Mechanical Acoustic. While the system-level model only required engineers to define boundary conditions at source and load surfaces, the component-level model enabled engineers to define and study one substrate layer at a time. As engineers completed simulations for each layer, the impedance results became a boundary condition for each subsequent layer.

To test glass performance under a range of real-world operating conditions, a variety of acoustic loads were applied to the model. By varying acoustic pressure, acoustic velocity and power intensity during their simulations, Corning engineers could determine how impedance was affected by different loads. When used by consumers, the outer glass surface could be contacted by air, solids or a mix of both — all of which are capable of producing acoustic energy. The development team needed to assess how this energy, whether applied intentionally or accidentally, might impact the product's performance.

One special consideration was that the glass would need to respond appropriately, accurately and reliably to a ring-based load applied to its outer surface. This was related to the final product's core functionality. This ring-shaped load might be distributed across the glass in a non-uniform manner — yet the product had to respond reliably and uniformly. This made the problem more complex, as power intensity and impedance were no longer constants during the simulations. The Ansys solutions were easily able to accommodate this requirement and replicate the needed physical conditions.

SIGNALING A SMART FUTURE

As Corning engineers calculated both wave propagation and acoustic impedance for the new glass product under diverse conditions, they were able to optimize its properties and minimize impedance by addressing any sources of resistance. By varying glass composition, material thickness and orientation, and other properties of the glass stack, engineers developed a final, optimized product that meets the customer's demanding smart-product application.

The Corning team recognized that each glass assembly has a unique acoustic signature in terms of coincident frequencies and impedance. For a given ultrasonic frequency, the team was able to optimize the material attributes to maximize sound wave transmission through the glass assembly, as well as its return from the loading surface back to the signal-detection side of the glass.

This problem of accurately transmitting ultrasonic waves through a stacked-glass substrate was unique to this customer, but it typifies the sophisticated physics problems involved in smart-product design. As smart products continue to evolve, Ansys simulation allows Corning to tackle advanced customer challenges quickly and accurately, and to support continuous innovation and rapid product launches.

Firefly conducts acceptance testing.

Ansys Startup Program Helps Companies Achieve Liftoff

The Ansys Startup Program has helped 1,000 new companies and counting since it began in 2016, doubling its rate of growth in just the last two years. The program provides entrepreneurs with full access to simulation bundles when their companies need it most.

Startups often have big ideas but limited funding to develop them into products. Without simulation software, startups would be at a disadvantage because they would be forced to perform time-consuming and costly physical prototyping while their established competitors can efficiently advance their product development initiatives via simulation. Companies in the Startup Program can test and modify hundreds of virtual prototypes in the time it would take to build one physical prototype.

"At Firefly, our work is quite literally rocket science," says Tom Markusic, CEO of Firefly Aerospace, in a recent press release. "It takes an enormous amount of simulation and modeling to design components that withstand the tremendous liftoff, flight and space environments. Leveraging the suite of Ansys tools allows us to ensure that a design works with limited test iterations, providing up to $5 million in cost savings in engine cooling design, $10 million in increasing engine thrust and up to $500,000 in mass optimizations."

Firefly Aerospace has graduated from the Ansys Startup Program, which it joined in 2017. The company uses Ansys products to fulfill its mission of providing economical and convenient access to space for small payloads through the design, manufacture and operation of reliable launch vehicles.

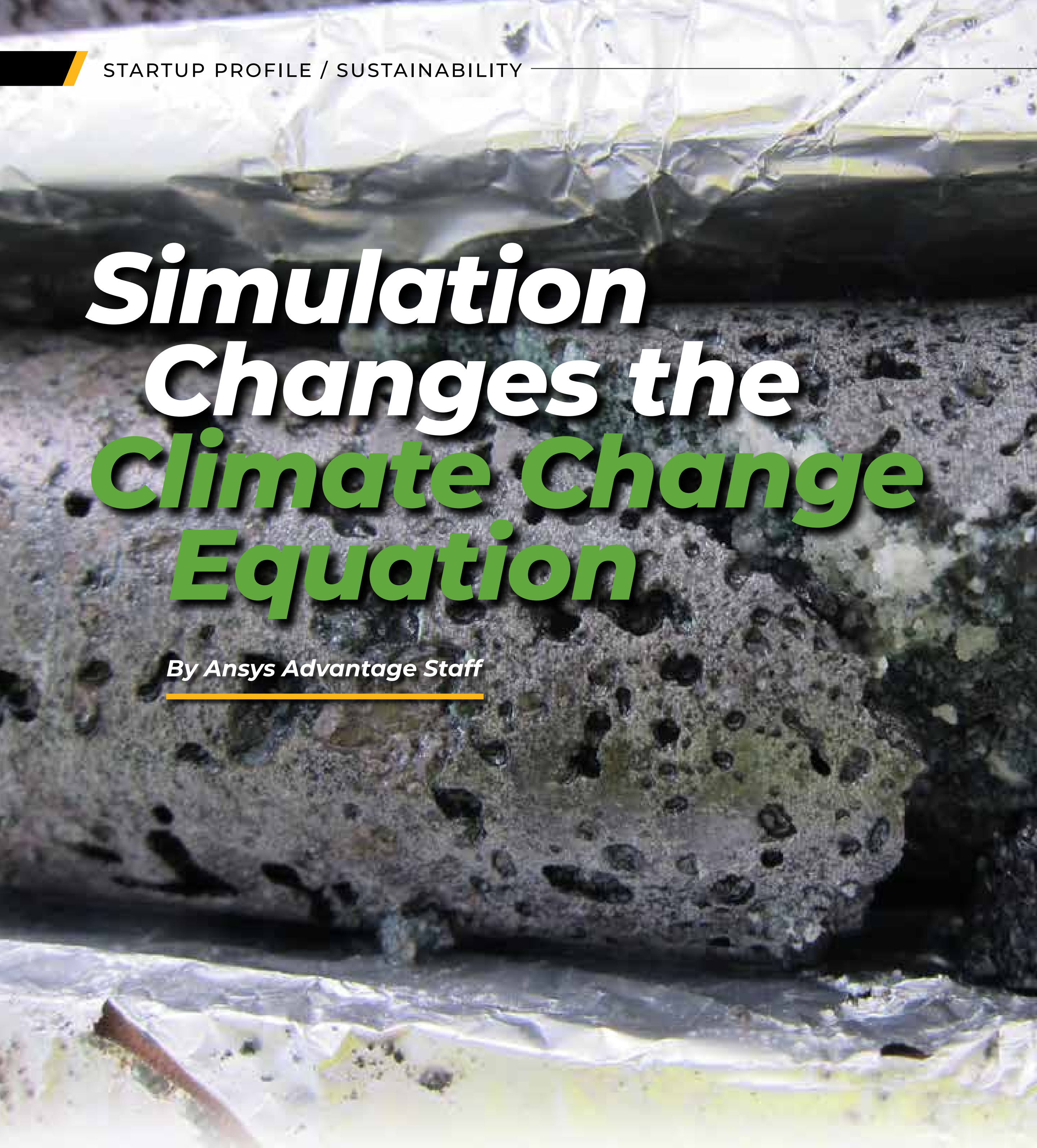
STARTUPS IN THE SPOTLIGHT

To celebrate the 1,000-startup milestone, Ansys is spotlighting some of the amazing companies that have participated in the Startup Program over the next few pages and in our blog at ansys.com/blog.

From rocket science and radar to 3D printing and electric powertrains, companies in the Ansys Startup Program are using simulation to make the world a better place. The Onward Project is a great example. This recent addition to the Ansys Startup Program is using Ansys Discovery to optimize the design of AdvenChair, an all-terrain, human-powered wheelchair.

"We created the AdvenChair so that people with mobility issues can continue enjoying the great outdoors, beyond where the pavement ends," says Geoff Babb, chairman of The Onward Project. "Upfront simulation is a necessity for us to make that vision a reality. We're implementing Ansys Discovery into our design process to reduce weight, maintain structural integrity and ultimately cut costs, resulting in a better, more budget-friendly product."

Ansys wants to help next-generation designs come to life by giving startups the necessary tools to overcome early-stage challenges associated with building physical prototypes. Learn more about the Ansys Startup Program at ansys.com/startups.



Simulation Changes the Climate Change Equation

By Ansys Advantage Staff

Considering the enormous climate implications of CO_2 emissions, it may be surprising to learn that the "high concentrations" of carbon dioxide we hear about aren't high at all. CO_2 molecules constitute only 0.04% of the Earth's atmosphere. The problem is, that's more heat-trapping CO_2 than has ever been recorded — a manmade increase of 45% since the beginning of the Industrial Age, with one-quarter of that occurring just since 2000.

Even a small increase in CO_2 contributes to the greenhouse effect, warming the planet, altering the Earth's weather patterns and directly affecting life as we know it.

To meet Paris Agreement climate standards, the world has to do more than stomp the brakes and reduce or offset CO_2 emissions. It has to reverse course by removing the emissions that are already in the atmosphere, and then either reusing or sequestering them, which means 0.04% is, indeed, a meaningful number in more ways than one.

Extracting CO_2 from the atmosphere isn't like squeezing water out of a wet sponge. At only 400 parts per million, CO_2 is exceptionally diffuse, making capture tedious and tough — and until now, quite expensive.

Swiss company Climeworks is tackling those challenges with its carbon dioxide removal solution. The company has developed a commercially viable, filter-based direct air capture (DAC) technology. By removing carbon dioxide from the air, it hopes to inspire 1 billion people to take climate action. By accessing Ansys simulation software as a partner in the Ansys Startup Program, Climeworks increased the filter capability of its DAC plants, streamlined the facilities' energy consumption, and reduced fatigue and failure risk under mechanical loading cycles.

Climeworks' goals are to:

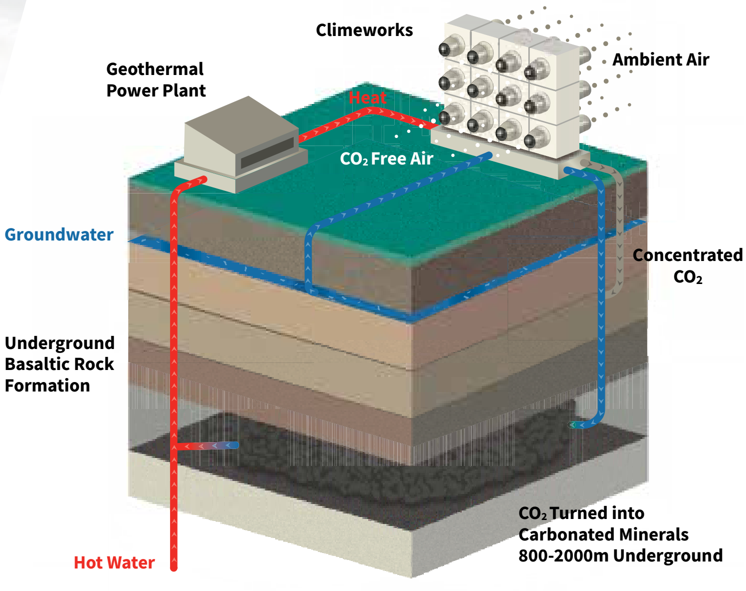
- Reverse the effect of CO_2 on climate change with direct air capture plants.
- Develop efficient plants to decrease captured CO_2 costs.
- Reuse air-captured CO_2 as a raw material for renewable fuels and materials.
- Remove CO_2 as a service.

Currently, there are 15 Climeworks DAC plants operating in Europe, some as commercial ventures, others for research. The flagship pilot plant in Switzerland can capture 900 tons of CO_2 per year; a facility under construction in Iceland will have the capacity to capture four times that amount.

DESIGNING SMALL AND SCALABLE, FOR BIG RESULTS

The concept of carbon capture and sequestration isn't new. In fact, it dates to the 1970s. The technology behind some methods goes back even further, all the way to the 1920s, when natural gas companies began separating CO_2 from their product streams.

There are three traditional ways of capturing carbon: post-combustion, pre-



Climeworks' direct air capture technology combined with the storage process developed by the Icelandic company Carbfix removes carbon dioxide from the air and stores it permanently underground. Image copyright Climeworks.

combustion and oxy-fuel combustion, which is used in power plants to burn fuel with nearly pure oxygen instead of air. But each of these is typically tied to collecting the emissions from a large point source such as the flue of a power generation facility or manufacturing plant, which requires industrial-scale capture facilities to be economical.

By contrast, Climeworks' DAC system is modular, consisting of multiple collectors that remove CO_2 from the air rather than from point sources. And instead of capturing CO_2 in a gas/liquid laminar flow like other approaches, Climeworks incorporates adsorbent air contact filters that the CO_2 sticks to. Climeworks also reduces or even eliminates the transportation costs associated with carbon capture: They can locate a DAC plant right on the storage site.

Climeworks direct air capture plant
Photo by Julia Dunlop

These innovations have reduced the size and price of Climeworks' plants.

ANALYZING 500 VARIATIONS

Climeworks' CO_2 collectors selectively capture carbon dioxide in a two-step process. First, air is drawn into the collector with a fan. CO_2 is captured on the surface of a highly selective filter material that sits inside the collectors. Then, after the filter material is full of CO_2, the collector is closed. Climeworks increases the temperature to between 80 C and 100 C (176 F to 212 F), which releases the CO_2. Finally, the high-purity, high-concentration CO_2 can be collected.

The gas is then either permanently and safely stored underground, where it can remain for millions of years, or repurposed in industrial applications. For example, the captured CO_2 can be turned into carbon black (a component in electronics, printing and construction), used for carbonating beverages, or processed into synthetic, renewable fuels.

Because CO_2 is so vast and dilute, capturing 1 ton requires moving 2,000 to 3,000 tons of air into small channels in the system. Climeworks engineers used Ansys Fluent to

ACCESSING SAVINGS AS AN ANSYS STARTUP PARTNER

Climeworks accessed discounted Ansys software through its relationship with CADFEM (Suisse), a member of the Ansys Elite Channel Partner network. CADFEM, a pioneer in the application of numerical simulation in product development, was an early investor in Climeworks, and the two companies maintain a close relationship.

The Ansys Startup Program gives entrepreneurs full access to simulation software bundles — including the Structural and Fluids bundle — that are built and priced to help businesses grow quickly and cost-effectively. This opportunity is especially important during the early stages of starting a business when funding is limited and there is little to no revenue.

analyze airflow volume and speed, understand pressure loss and how it affects the system's energy consumption, reduce pressure drop, and optimize sorbent volume, that is, how much CO_2 will stick to the solid material air contractor filter.

Each plant works in batch mode, with the heating and cooling process beginning only after the filter is saturated. Because releasing the gas and regenerating the collector creates a vacuum in the collection chamber — and the cycle is repeated thousands of times — engineers used Ansys Mechanical to simulate structural stress and fatigue.

Altogether, engineers modeled 500 geometry variations of the air collector while perfecting their design, and did it in far less time than it would have taken to test and build one physical prototype. In fact, engineers estimate that simulation was five to 10 times faster than physical testing would have been. And time savings is cost savings — for Climeworks, its customers and, ultimately, for a planet trying to avoid the high price of climate change.

Leading scientific studies indicate that by mid-century, 10 billion tons of carbon dioxide will need to be removed from the air every year. Using Ansys software, Climeworks has developed a direct air capture solution that can contribute to that lofty goal.

Climeworks-captured CO_2 turned into stone with the Carbfix process. Carbfix developed a process that captures CO_2 and other acid gases in water, then injects this water into the subsurface where the gases are stored as stable minerals.
Credit Carbfix. Photo by Sandra O Snaebjornsdottir

Climeworks founders Christoph Gebald (l) and Jan Wurzbacher in front of the Climeworks plant
Copyright Climeworks. Photo by Julia Dunlop

Supashock Smoothly Expands Business with Simulation

Supashock began in 2005 by focusing on how shock absorbers could be improved for the racing industry and has since expanded into developing suspension and mobility systems for many other applications.

By **James Browne**, Senior Structural Design Engineer, Supashock, Adelaide, Australia

From his years of experience as a race car engineer, Supashock founder Oscar Fiorinotto knew that tires and shock absorbers were considered “black arts” rather than well-understood components of race cars. Even cutting-edge shocks left a lot to be desired in damping out the bumps and swerves that a race car experiences on a track. Driven by his passion for understanding and controlling motion, Fiorinotto started disassembling shocks and analyzing their operation at a time when there was very little engineering literature about how they worked. Eventually he discovered the critical elements of shock absorbers and founded Supashock in 2005.

But, as with most startups, the going wasn't easy. After being turned down by all the major automotive original equipment manufacturers (OEMs) in Europe when he tried to sell his new shock absorber design to them, Fiorinotto was heading back to his native Australia disappointed. As a last resort, he asked a race car–owning friend if he would take a chance on his shock absorbers for an upcoming world-class championship race. The friend agreed. On race day, the car completed the first laps a half-second faster than it ever had before — a major improvement in auto racing circles. The car, which normally finished in the back of the pack, finished second that day. A representative from one of the OEMs in attendance, who had recently rejected Fiorinotto's sales pitch, approached him after the race about setting up another meeting. But Fiorinotto had already made a commitment to the new team.

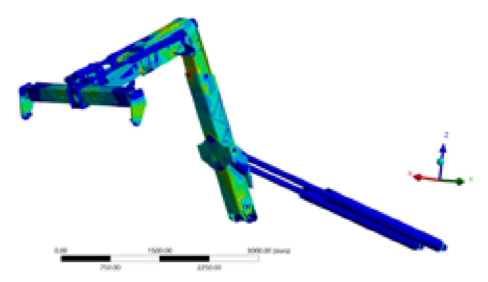
Over the years, Supashock has been successful in designing and manufacturing suspension and mobility systems for consumer cars, race cars, mining vehicles and armored military vehicles, among others. In 2016, Fiorinotto first began working with LEAP Australia, Ansys Elite Channel Partner for Australia and New Zealand, to apply Ansys Mechanical software to Supashock's shock absorber designs. By conducting virtual tests of new shock absorber designs, it was immediately clear to Fiorinotto that in addition to saving both time and money, simulation also provided his team with the right tool to accelerate the pace of innovation that was occurring within his engineering team.

THE CHALLENGE OF SHOCK ABSORBERS

Shock absorbers are critical components for vehicle dynamics. They enable pinpoint handling in tight curves on a racecourse and are the difference between the bumpy ride you might be getting from a low-end consumer car compared to the precise handling yet still comfortable ride of a luxury car.

Suspension systems contain both springs and dampers (commonly referred to as shock absorbers or just "shocks"). A damper consists of an internal rod that slides in and out of an external cylinder, forcing a viscous fluid through orifices to control the speed of the suspension motion. The spring, which may be a traditional coil or even a gas spring, is often included in the same structure. The spring and damper must be tuned together in order to produce the optimum compromise between ride comfort and handling performance.

These dynamic structures experience many different loads during operation, and they must perform well and maintain structural integrity through their life (remembering that in some vehicles, this structure is literally holding the wheels on the car!). This means that, depending on the type, the shock absorber needs to be analyzed in a variety of positions, ranging from fully extended (droop) to fully compressed (bump) with differing loading conditions.

Supashock has expanded into logistics and handling technologies. The company uses Ansys Mechanical's topology optimization to reduce the pictured loading system weight and speed without reducing capacity.

James Browne, Senior Structural Design Engineer, Supashock, uses Ansys solutions to help develop new products and optimize existing ones.

The internal rod's motion is constrained by a sliding contact, with linear bearings that allow the low friction, axial movement of the rod as the wheel moves up and down. As a result, the FEA models require nonlinear contacts. Fatigue must also be considered due to the long life and repeated loads experienced by vehicles.

SIMULATING A NEW SHOCK ABSORBER DESIGN

Supashock's eight design engineers start with a computer-aided design (CAD) model of a shock absorber and defeature the geometry in Ansys SpaceClaim, removing thread details and features that are not structurally relevant to simplify it for simulation.

The "share topology" function in SpaceClaim is used to combine joined components (such as at welds). After meshing the model, usually an initial linear solve is performed within Ansys Mechanical, representing bushings as joints and applying forces and pressures to make sure the model behavior is valid, prior to introducing additional complexity with nonlinear contacts.

As the shock absorber is often required to be analyzed in a variety of different positions through its stroke, either the "configure joints" or "body transformation" feature of Ansys Mechanical is used to move the rod relative to the cylinder, without having to re-import the altered geometry from SpaceClaim. This has proven to be a more efficient workflow than modifying the geometry itself.

THE AUTOMATED LOAD HANDLING SYSTEM

Over the years, Supashock has expanded well beyond racing. For example, the company now supplies products to the defense industry for military vehicles. Rheinmetall AG of Germany is one of their major customers in this field, and a key partner for Supashock in the development of mobility and logistics handling technologies.

In 2017, Rheinmetall presented Supashock engineers with a big challenge: Design a new automated load handling system (ALHS) that could rapidly and automatically load a shipping container or DIN/STANAG roller container (or flatrack) weighing up to 16.5 metric tons onto a Rheinmetall military truck without outside human intervention.

Existing load-handling systems required a person to leave the safety of an armored vehicle to connect the loading device to the shipping container, which is an obvious danger in military situations. Rheinmetall wanted a system that could be operated by one person inside the armored vehicle and, if possible, complete the loading process in record time. The loader also had to be as light as possible because every kilogram of mass in the loader was one less kilogram of payload that could be transported.

The solution to this challenge was to design a hook loader that lifted the container from the top with connections at only two points, as compared to the existing loader that had a frame that required a human to connect it to the container at its four edges. The first question that arose was whether a standard shipping container could withstand the forces involved in being lifted from only the top. A quick simulation in Mechanical showed that it could.

By far the biggest challenge was analyzing all of the load cases involved in a hydraulic lifting system undergoing a large range of motion with many degrees of freedom in order to complete the loading sequence while compensating for misalignment and payload variations.

In these scenarios, the "configure joints" feature was used to produce a time-efficient workflow. Traditionally, an engineer would have to reset the model for each of these load cases from the geometry, altering the CAD model in the preprocessor and re-importing it into Mechanical. Using the "configure joints" functionality, the translational joints in the hydraulic cylinders were used to move the structure to check different positions in the loading sequence.

As well as looking at individual loading positions, by using "large deflections" the full range of motion was assessed in one solve by providing the relative hydraulic cylinder displacements in different time steps though the loading sequence.

The output of this solve stores the stresses/displacements of the structure at all of the time steps through the loading sequence, allowing a "maximum stress over time" and "time of maximum stress" plot to show the magnitude and the position in the loading sequence that causes the greatest stress in the structure.

A graph of all the loads on the hydraulic cylinders throughout the full loading sequence was compared and cross-validated with spreadsheet calculations based on a free body diagram of the system, giving them confidence that they had correctly sized all the actuators.

Ansys Mechanical's topology optimization feature has also helped Supashock to significantly reduce the overall weight of the loading system by identifying where mass could be taken out of the structure without compromising the required stiffness or producing stresses over allowable limits. This enabled significant weight savings, critical for maximizing the payload.

Physical strain gauge testing as well as measurements of hydraulic cylinder pressures from testing, after the load handling system had been constructed, confirmed the accuracy of the Mechanical simulations that were performed during the project design phase.

A HISTORY OF SUCCESS

Rheinmetall had requirements and a vision for a loading system that was capable of lifting a container from the top without human intervention. Supashock took their requirements and successfully turned it into an operational system. The ALHS can now load a container in half the time it took with conventional loaders, with no human intervention — meaning that the operator can remain safely within the armored portion of the vehicle. With the help of Ansys Mechanical, Supashock engineers designed the ALHS to increase the capability and speed of loading without sacrificing payload capacity.

Let's not forget the shock absorbers that were the beginning of Supashock's success and that continue to be improved each year. In 2019, the Supercars Championship — Australia's top-level racing championship — decided to standardize one homologated shock absorber for all competing teams. Supashock was chosen to be the sole supplier of shocks to the Supercars Championship starting in 2020 — a major victory for a company that got its start by exceeding all expectations on a global stage as an Australian SME against the giants of the industry. Supashock also supplies the control shock absorber for New Zealand's Toyota Racing Series, the premier open wheel series in New Zealand.

Supashock's use of Ansys is supported by Ansys Elite Channel Partner, LEAP Australia.

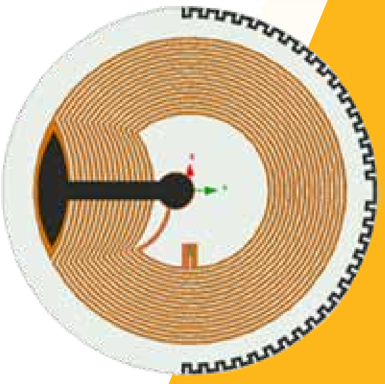
Nikola Labs' Vero system

Startup Beams Power to the IoT

By **Roland Tallos**, Chief Engineer, Nikola Labs, Columbus, U.S.A.

Wirelessly powering devices may seem like a new idea, but its origins go back as far as 1899, when Nikola Tesla built and demonstrated the Tesla Experimental Station in Colorado Springs. His high-voltage, high-frequency experiments proved the concept of wireless power rather too dramatically: The artificial lightning generated millions of volts and caused sparks to jump between nearby pedestrians' feet and the ground.

Today, research and engineering teams are working on much lower power systems to wirelessly recharge things like smartphones and Industrial Internet of Things (IIoT) sensors. Nikola Labs in Columbus, Ohio, is working on the industrial side of this challenge. A participant in the Ansys Startup Program, the company was founded in 2015 at Ohio State University to commercialize the ideas of Professor Chi-Chih Chen, which involve transfer of power through radio frequency (RF) electromagnetic waves transmitted between antennas. The company now has about 30 employees dedicated to providing an end-to-end solution for remote machine condition monitoring. Machine health is measured using an ultra-low power receiver composed of a temperature sensor and an accelerometer. While the receivers currently operate in the field for long periods of time on a single battery charge, they could eventually benefit from the wireless power technology that Nikola Labs is developing.



HFSS model of the meandered dipole antenna around an NFC antenna

But, like many startups, they had to design and demonstrate prototypes for many different potential clients with a wide range of applications before they hit on vibration sensor technology. And they are still looking for opportunities in other verticals, like smart buildings, to expand their business. One thing has been constant along the way: Ansys HFSS.

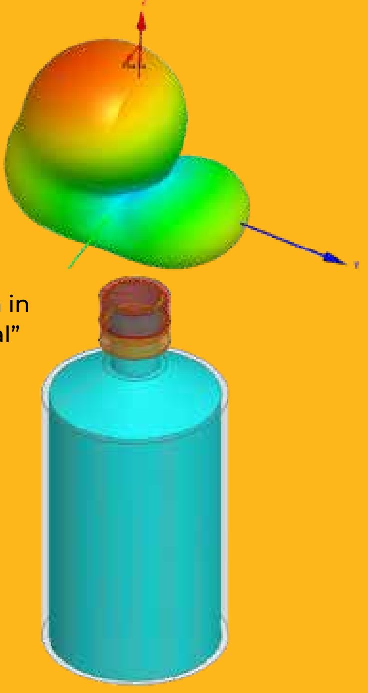
AN EARLY START WITH SIMULATION

Coming up through the graduate program in electrical engineering at Ohio State, the first engineers hired by Nikola Labs were familiar with the workings of HFSS because they used it in the classes and projects they needed to graduate. They came to know HFSS inside out and to trust its accuracy.

When the VP of Operations at Nikola discovered that they could access two seat licenses to HFSS at a much reduced cost because they were a startup company, they quickly joined the Ansys Startup Program and used HFSS in all the exploratory projects that came their way.

WIRELESS POWER EXPLORATORY PROJECTS

Early on, a company approached Nikola Labs about using wireless power to replace the battery in a battery-assisted passive (BAP) near-field communication (NFC) tag to boost its read/write range. Instead of using batteries that required maintenance, they wanted to use energy harvested from a 2.4 GHz transmitter source that was part of the NFC reader to supply the bump in power needed to increase the read/write range. The company already had an antenna on top of a bottle cap and wanted Nikola to provide a wireless power solution in the small space around this antenna. That involved designing a “conformal” antenna that would fit around (conform to) the existing 13.56 MHz NFC antenna and accompanying NFC integrated circuit (IC), all in a diameter of about 1 inch. Nikola’s antenna design received 2.4 GHz RF power to supply their energy-harvesting system-in-package (SiP). The SiP then converted the RF power to DC power for the NFC IC, increasing the read/write range without using a battery.



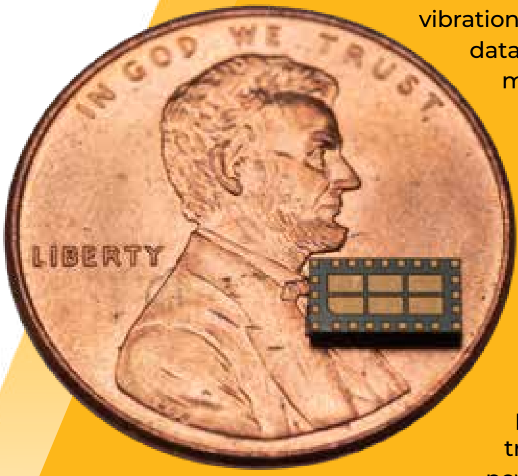
The 3D radiation pattern of the dipole antenna when it is mounted on top of the bottle

Using HFSS, Nikola Labs engineers first modeled basic antenna geometries around the NFC antenna, keeping everything planar at first to minimize initial simulation time. To fit into the small diameter available, they decided to use a meander dipole antenna, the shape of which “meanders” back and forth to fit a long antenna length into a small space. They took advantage of the parametric sweep feature of HFSS, studying a number of variables to gain an understanding of how the different values for the variables would affect the design. Nikola engineers were able to show that a horizontal dipole around the NFC antenna, which acted as a ground plane, could harvest enough energy to make this solution feasible. Then they began to add more details to the simulations, from the copper trace thicknesses on the board all the way up to the whole bottle filled with liquid. They eventually built a prototype and demonstrated that it worked, but for various reasons the client decided to go in another direction.

Another company wanted to use wireless charging technology to power a temperature and humidity sensor in an office space. The goal was a more efficient heating, ventilation and air conditioning (HVAC) system. They also wanted to include solar cells that would absorb some of the energy of office lights to capture a portion of that normally wasted power. The device had to be small to be integrated into the top of a cubicle wall or an office desk with the power source above it in the ceiling. Nikola Labs realized that they needed a split beam antenna pattern with hardware to control the angle of the two beams pretty tightly, and there did not seem to be enough space. So they used HFSS to figure out how to configure the size, shape and materials of the antenna system to guide the beam at the correct angle. This involved varying the size and type of substrates and the dielectric material using parametric sweeps. Again, the prototype was a success but the project did not go forward — a rather typical series of events for a startup looking for its niche.

FINALLY, THE RIGHT PROJECT

In 2017, Nikola Labs was approached about designing a sensor consisting of a receiver with an accelerometer to monitor the condition of machines through vibrational analysis. Accelerometer data can be converted into vibration data, which experts can review to learn about the condition of a machine — like a motor housing or bearing housing, typical points of wear and tear in industrial settings. Existing sensors of this type have a short battery life, which requires continual maintenance for battery replacement. Nikola engineers are tackling the battery life problem in two ways. First, they focused on designing the receivers to be ultra-low power, extending the system life off a single battery charge. Then, they used HFSS to focus on the RF side to design antennas that they use to harvest RF power. The harvested RF power is then fed to their energy-harvesting system-in-package, which consists of an RF-to-DC rectifier circuit and a DC power management circuit together in a tiny package. On the transmission side, they simulated different transmitters to beam power to the receiver. In this way, Nikola engineers are working toward marrying the sensor with their wireless power technology to transfer data to the sensors and provide power wirelessly, extending the sensor life up to 10 years or so.



RF-to-DC system-in-package
(penny included for scale)

One of the systems under development has a hub, which is a router that collects the data from the sensors and transmits wireless power to them. The sensors are mounted on the industrial equipment being monitored. Current wireless technology can harvest only 100 microwatts on average, so that has to be sufficient to power the system. The question becomes how often can you turn your sensor on, gather the data and send it out given the small amount of power that is being harvested? Striking a good balance is essential to optimizing sensor life. Currently, data is gathered from the sensors at least eight times a day. The distance between hub and sensor is ideally no more than about 5 meters, because that distance is the break-even point in terms of power harvested vs. power consumed. The system under development powers about six sensors per hub now, but that number could be higher if the power balance were optimized and system performance were increased.

Customers are always asking for smaller components, which is a strain on the hardware. With the power available for transmission being fixed, and no large gains to be made on the RF to DC side of the system. The biggest impact possible is on the performance of the harvester's antenna on the receiver side. To optimize this impact requires being able to rapidly simulate numerous types of antennas using different techniques and different designs. Being able to iterate quickly is a major advantage of HFSS. Nikola engineers use HFSS to quickly iterate and vet new ideas and new materials for antenna design. HFSS is also used on passive RF circuits, like power splitters, combiners and filters. As a final check, Nikola engineers import the printed circuit board (PCB) geometry into HFSS to run simulations to ensure that everything is behaving correctly before prototypes are made.

MACHINE LEARNING OPTIMIZATION ON THE HORIZON

By focusing on the vibration sensors for the last year and a half, Nikola Labs now has 40+ customers with 70+ facilities, with numbers on the rise. They currently monitor over 900 major pieces of industrial equipment and have collected more than 32 million readings to date.

Ultimately, Nikola engineers want to use the data they collect to develop machine learning techniques to further optimize the performance of the equipment. They are also looking for opportunities in other IoT verticals, like smart buildings. When they find them, HFSS will be in their toolkit to take on the toughest challenges.

Collaborate on Seamless Optics Design for ADAS

By **Sanjay Gangadhara**, Chief Technology Officer
Zemax, and
Ludovic Manillier, Business Developer
Ansys OPTIS

Simulation via Ansys SPEOS replicates how an ADAS camera "sees" a vehicle's physical surroundings in daylight, nighttime and foggy conditions.

WINNING IN TODAY'S CROWDED AUTOMOTIVE LANDSCAPE means being first to market with increasingly autonomous vehicle designs. One obstacle? A disconnected workflow that increases the time and cost of developing the advanced optics underlying ADAS perception systems. A new technology partnership between Ansys and Zemax is making the optics development process exponentially faster, helping customers reach the finish line first.

A recent report from the U.S. National Highway Traffic Safety Administration revealed that errors made by human drivers cause 94% of the 40,000 car accidents that occur in the U.S. annually. Advanced driver assistance systems (ADAS) — including forward collision warning, automatic braking, lane keeping and pedestrian detection systems — are critical to minimizing the tens of thousands of crashes caused by driver distraction or inattention each year.

PERCEPTION PERFORMANCE CHALLENGES

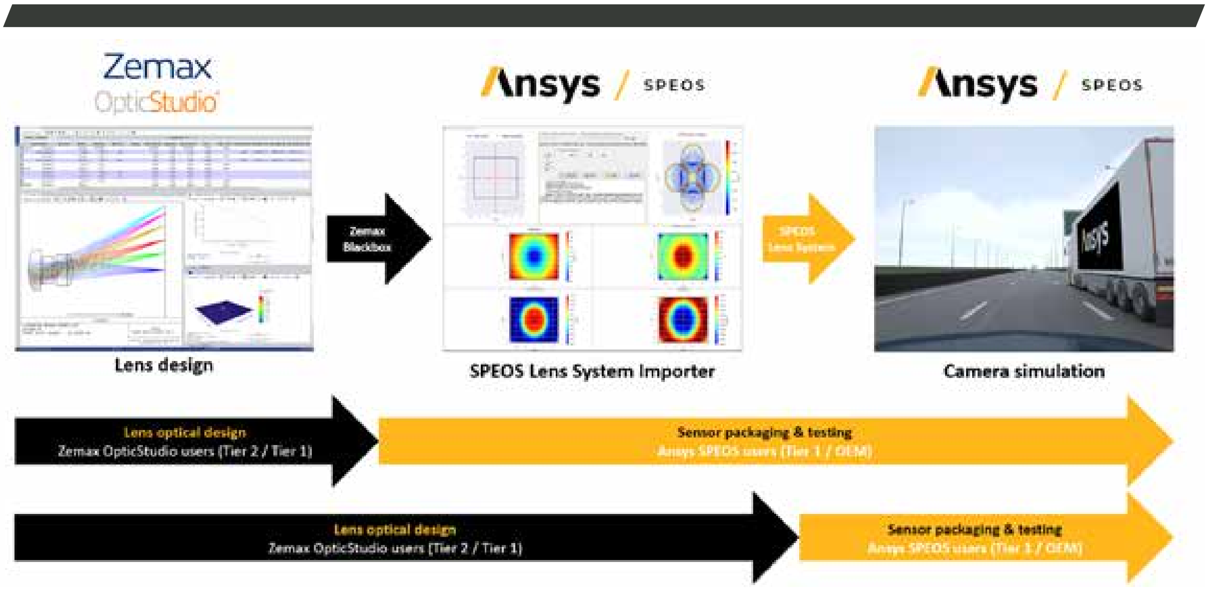
As automakers and original equipment manufacturers (OEMs) race to develop new ADAS technologies that increase the level of automotive autonomy and minimize the element of driver error, perception systems are a mission-critical component. The concept of driver assistance relies on the ability of the vehicle's sensors to accurately detect hazards like pedestrians and trigger an appropriate response from braking, steering and other systems.

The essential role played by perception technologies means that today's automotive development teams must work quickly and cost-effectively to launch innovative new ADAS sensors, including advanced optics that work under a range of weather conditions, lighting levels, ambient temperatures and other operating parameters.

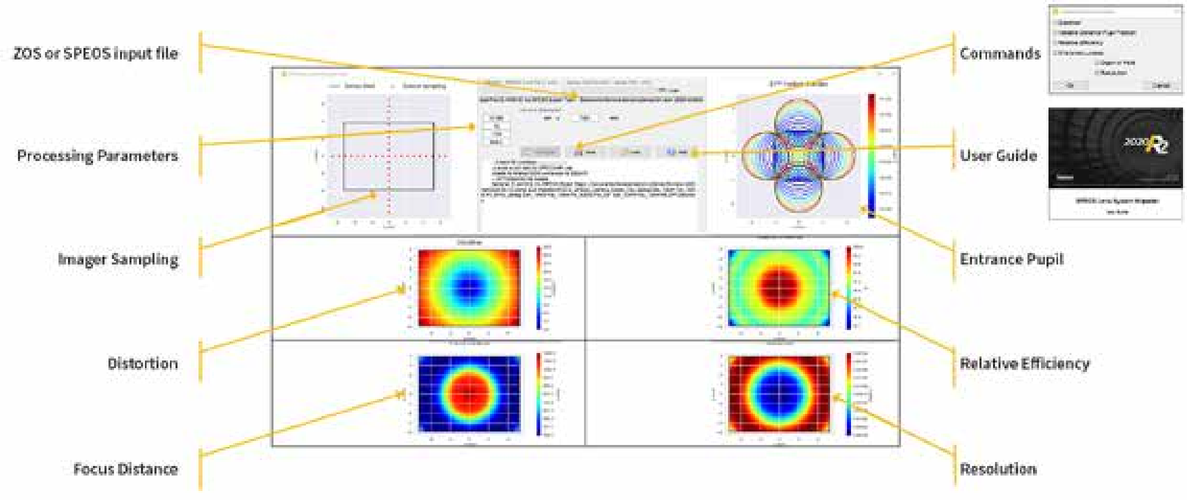
Each ADAS optics component must be optimized for a specific use case, which considers its position on a vehicle and its primary function. For example, an optical component might support a back-up camera used in parking lots, or a front-mounted camera that triggers the emergency braking system when a pedestrian is detected on the road ahead. Optics may or may not need to have strong peripheral vision. They almost universally need to function well under a range of weather and lighting conditions.

These performance characteristics influence a range of design choices, from lens shape and profile to choice of materials. All these factors combine to make the task of ADAS optics design extremely complex. Equally complex is the job of verifying that these optics will perform reliably when mounted on a vehicle and exposed to real-world driving conditions.

Two engineering solutions have been proven to meet these challenges, leading to the rapid



By partnering to import the Ansys SPEOS lens system simulator directly into Zemax's OpticStudio, the two companies have eliminated the functional and technological obstacles to seamless ADAS camera design.



An easy-to-use interface in the Ansys SPEOS lens system importer makes it simple to control the simulation parameters and verify accurate lens performance under a variety of lighting and atmospheric conditions.

development of ADAS optics. Zemax's OpticStudio and Ansys SPEOS are often used in combination to first design the lens, then simulate its performance in a static or dynamic driving situation. These tasks are managed by two different teams — an optical engineering team and a virtual testing team — which necessitates hand-offs and collaboration.

The outdated, functionally siloed workflows that support the optics development process represent one of the biggest obstacles faced by these teams. Historically, optical engineers have developed a lens model inside Zemax's industry-leading optical design software, OpticStudio, then moved the model manually to Ansys SPEOS for camera simulation and performance verification by the virtual testing team. Because data was exported manually and mathematically complex calculations — including raytracing — needed to be remodeled in SPEOS, this process was slow and error-prone. Following the initial simulation, any design iterations followed this same tedious and time-consuming process.

The result? Slow launch schedules and significant budget overruns. Worse, many development teams had concerns about data security and intellectual property (IP) protection as designs were repeatedly handed off among different development functions and disparate technology tools.

ZEMAX AND ANSYS: A CLEAR SOLUTION

Recognizing that this manual process represents an obstacle to rapid ADAS innovation, Ansys and Zemax have collaborated to link their industry-leading solutions via a secure technology interface.

The Ansys SPEOS lens system importer, created in a partnership between Ansys and Zemax, is designed to streamline workflows and protect IP.

This new end-to-end solution for camera testing and validation leverages the component-level design, modeling and simulation capabilities of Zemax's OpticStudio with the modeling, simulation, analysis and visualization benefits of Ansys SPEOS. As a result, engineers developing advanced optics for ADAS camera designs can quickly and accurately test, validate and iterate their designs.

The SPEOS lens system importer is built on top of the highly functional and flexible OpticStudio Application Programming Interface (ZOS-API), allowing it to be used to bring any camera lens design from Zemax's OpticStudio, into Ansys SPEOS simulation software. The entire optics model can be transferred using the secure "black box" technology in OpticStudio, so IP is protected without limiting the simulation analysis. All data is securely and automatically pulled into the simulation tool, without any need to recreate key calculations. The simulation can begin immediately — leading to an end-to-end development process that is exponentially faster than the historical, manually intensive workflow.

The new streamlined workflow is already benefiting Ansys–Zemax customers, including Continental. "Ansys offers the automated execution of simulation plans to solve complex problems in the design of autonomous vehicles," said Konrad Rothenhäusler, design for Six Sigma Coach, ADAS business unit at Continental. "The end-to-end optical testing solution from Ansys and Zemax enables us to exchange optical transfer functions — which determines the quality of the projected image — while protecting our sensitive design data. This workflow will empower our team to explore new camera designs faster, cheaper and with less risk."

The Ansys SPEOS lens simulator has the power to simulate multiple camera lenses mounted on ADAS-equipped vehicles under dynamic driving conditions.

A VIEW TOWARD IMPROVED PRODUCTIVITY

So how exactly does the accelerated and streamlined process work? First, optical engineers design a complete optics system in Zemax OpticStudio, performing comprehensive design optimization and tolerancing. The resulting virtual model considers every factor that might impact the quality of ADAS perception systems, including lens geometry, lens position, materials composition and the effects of stray light.

The SPEOS lens system importer generates a model of the complex Zemax camera design, then brings it directly into Ansys SPEOS for simulation and physical verification. While it includes key calculations and dimensions, the model protects any sensitive IP that went into the development of the lens, providing a higher level of security for optics engineers.

Whether the sensor's output is projected on a screen or displayed in a virtual reality environment, Ansys SPEOS provides ADAS engineers with a visual simulation of their optical system as installed on a car. Ansys SPEOS supports both static and dynamic simulations, on a highway or in a parking lot. It can consider a range of ambient lighting conditions, such as nighttime, as well as the full range of operating temperatures that might affect a car. Ansys SPEOS can also simulate atmospheric conditions including fog, which has proven especially problematic for the designers of ADAS perception systems. To fully replicate real-world operating environments, SPEOS can combine a variety of conditions — for example, nighttime/hot/foggy or daytime/cold/clear.

Based on the Ansys SPEOS simulation, optical engineers can then improve the perception quality of their cameras and lenses in Zemax OpticStudio by re-optimizing their designs. OpticStudio supports comprehensive and easy-to-use tools to target properties such as image brightness and image sharpness as a part of the optimization process, and it also provides robust simulation of camera performance over the large fields of view typically required by ADAS perception systems. The new lens model can easily be imported into Ansys SPEOS for additional simulation and verification. By significantly speeding up the iterative design process, the new Ansys–Zemax technology integration helps ADAS development teams get fully validated opto-mechanical designs out to market faster.

ENVISIONING AN AUTONOMOUS FUTURE

While the immediate goal of ADAS technology is to minimize the number of crashes caused by driver error, certainly the long-term goal is to support fully autonomous driving. By improving and accelerating the design process for sensor optics — and leveraging simulation to reduce physical testing and prototypes — the Ansys–Zemax technology partnership is helping automotive customers like Continental to seize leadership in the race to commercialize a fully autonomous, or Level 5, vehicle.

By reducing the time and cost of product development, while fostering ADAS optics innovations, Ansys and Zemax have joined forces to address a critical customer need. As automakers and OEMs acquire and apply an increasing number of advanced engineering tools, it is incumbent on technology providers to ensure that these solutions are optimized for tight integration — and the rapid results that lead to success in a fast-moving, highly competitive industry.

Use CFD to *Improve Efficiency and Reduce Emissions*

Duraivelan Dakshinamoorthy
Vice President
Tailwater Technical Consulting LLC
Houston, U.S.A.

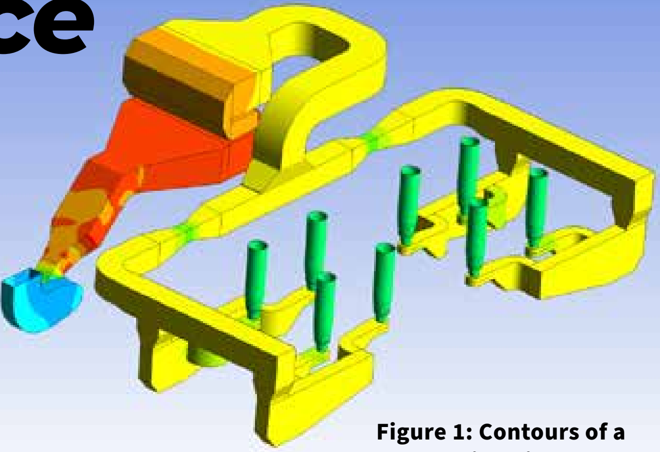


Figure 1: Contours of a combustion air pressure profile across a forced draft fan, air preheater, air plenum and burner

Energy efficiency is essential to convert crude oil and natural gas into fuels that provide energy to the entire world. Simulation enables the oil and gas industry to improve efficiency and reduce emissions of fired heaters.

Fired heaters are the energy workhorses of the oil and gas industry. In a fired heater, thermal energy is released by combustion of fuel (gas, oil or both) and is then transferred to process fluids via radiant and convection tubes. However, all the energy supplied by combustion is not transferred to the tubes; thus fired heaters are major consumers of energy within the oil and gas industry. Improving the efficiency of the heaters decreases energy consumption, thus reducing operating costs. In the current environment of low crude oil prices, a penny saved is a penny earned.

Fired heaters produce waste flue gas from the combustion process that is discharged to the atmosphere. Flue gas is primarily nitrogen (N_2), carbon dioxide (CO_2), water vapor (H_2O) and oxygen (O_2). In addition to this, flue gas may also contain small concentrations of pollutants (emissions) that include carbon monoxide (CO), nitrogen oxides (NO_x), sulphur oxides (SO_x), particulates and metals. Emissions are harmful to the environment, and efforts must be made to reduce the pollutants from the fired heaters and meet strict environmental regulations that limit emissions from fossil fuels.

To improve efficiency and reduce emissions, proper understanding of fired heater design is essential. Ansys Fluent is now used extensively by the oil and gas industry while designing fired heaters. Fluent allows engineers to visualize design details in the front-end engineering design (FEED)/detailed engineering stage of the project, where cost of change is minimal. The following cases give a glimpse of how Fluent

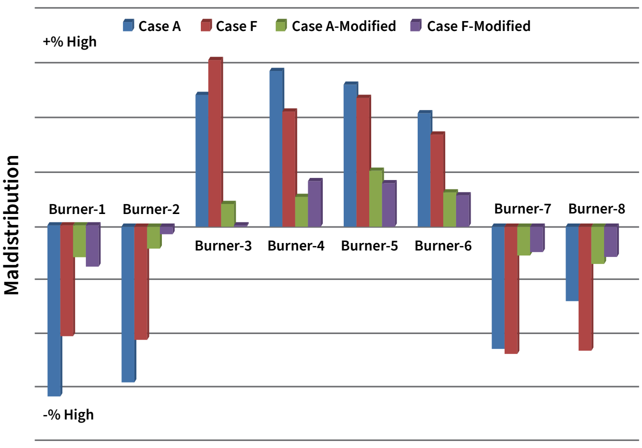


Figure 2: Maldistribution improvement for proposed modified design

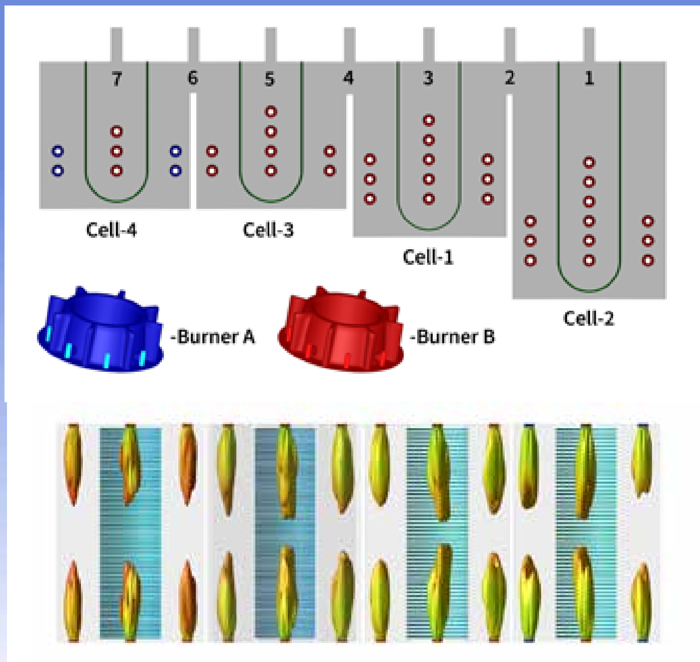


Figure 3: Flame shapes for multiple cell, multiple burner heater

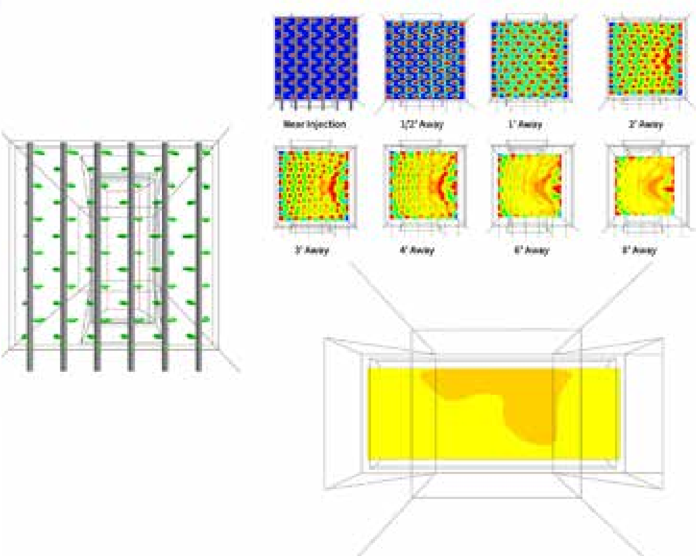


Figure 4: Aqueous ammonia profile in flue gas from injection point

is used in improving efficiency of the heater and reducing emissions.

COMBUSTION AIR DUCTING DESIGN TO CONTROL EXCESS AIR

For complete combustion, air in excess of the stoichiometric amount is needed. Fired heaters are usually designed to receive 10% to 15% excess air. Too much excess air will reduce the efficiency of the heater and increase energy consumption. Engineers employ various means to deliver the proper amount of excess air to fired heaters. Natural draft heaters are most common. They are simple and reliable, as the air is drawn into the burners by the draft in the radiant section. Forced draft heaters require a forced draft (FD) fan to supply the air at the higher pressure. The fans provide better mixing so one can have multiple smaller burners. In some cases, forced draft heaters are equipped with air preheaters (APH) to improve the heater efficiency. Since air is supplied through a manifold and an air plenum, the design engineer must make sure air is supplied uniformly to all the burners.

Fluent is extensively used in investigating and eliminating maldistribution concerns during the design stage. Maldistribution, if undetected, would force the fired heater to operate with a higher rate excess air or a lower efficiency. Figure 1 shows one such combustion air ducting system. The system was modeled from the intake of the FD fan to the individual air plenums. The combustion air passes through the APH and the venturi flow meters along the way. Maldistribution was identified and eliminated using Fluent (see Figure 2).

COMBUSTION FLAME PROFILE MODELING

Burner manufacturers are focused on finding different means to limit NO_x from the burners, and computational fluid dynamics (CFD) has played a major role in developing and designing the next generation ultra-low NO_x burners (ULNBs). In most cases, fuel/air staging methods are used in limiting NO_x from combustion, which often leads to cooler but longer flames.

In a large furnace with multiple ULNBs, there is the possibility of flame-to-flame interaction and flame impingement on tubes. The flame length is often a critical burner parameter that is required for proper placement of burners and radiant tubes. The flue gas recirculation in the radiant box also affects the flame pattern.

When designing fired heaters with multiple ULNBs, Fluent is often used in modeling the combustion process in the radiant section. Figure 3 shows one such complex fired heater with four radiant sections (cells) with multiple burners. The flame patterns were identified and checked for interactions with neighboring burners. Radiant heat transfer was modeled and the resultant tube metal temperatures on the radiant tubes were predicted. Hotspots with higher radiant heat flux often pose coking concerns. Fluent identified this in the design, and changes were made to reduce the hotspots.

DESIGNING SCR SYSTEMS TO REDUCE NO_x EMISSIONS

NO_x emissions can be controlled by two methods: pre-combustion technologies (use of ULNB, flue gas recirculation, etc.) and post-combustion technologies. Selective catalytic reduction (SCR) is a post-combustion NO_x reduction technology.

With SCR, aqueous ammonia (NH_3) is injected into the flue gas using a carrier stream (air) through an injection grid (AIG). The injected ammonia mixes with the flue gas containing NO_x in the flue gas duct. The mixed stream is then sent to the SCR unit, which contains a catalyst bed. Ammonia then reacts with the NO_x in the catalyst bed to form nitrogen and water. This technology requires an effective injection system and an optimized duct design for better emission reduction. Mixing is usually challenging, because the amount of injected ammonia (ppm) is very small compared to the flue gas volume. Figure 5 shows an SCR unit with an upstream duct containing the AIG. Fluent is used in designing the injection grid and the upstream duct. The post-processing tools in Fluent allow engineers to understand how the injected ammonia mixes with the flue gas as it reaches the catalyst bed (see figure 4).

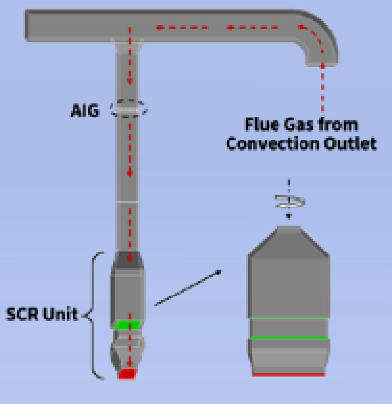


Figure 5: Selective catalytic reduction unit and ammonia injection grid design

Properly designed heaters operate safely and efficiently with controlled emissions. Controlling excess air reduces fuel consumption and increases efficiency. Understanding flame patterns and resultant tube metal temperatures increase longevity of the heaters with minimized risk of unforeseen shutdowns. The SCR unit's emission reduction efficiency increases with an effective injection grid and an optimized upstream duct design.

In all the cases discussed, Fluent has played a key role in the heater design and has added real engineering value.

Simulation in the News

Honeywell Driving Digital Transformation With Ansys

October 2020

Ansys is providing Honeywell with solutions that span the engineering design chain and help optimize the testing and simulation processes that are critical to taking products from the concept phase through to completion. Honeywell customers will see products come to market faster than before and reduced costs in the long run as cycle times shorten, thanks to the multiyear agreement.

LG Electronics Drives Company-wide Remote Learning with Ansys

November 2020

LG Electronics (LGE) is reimagining how engineering teams learn simulation to expedite the design of improved products, using an on-demand virtual learning portal created by Ansys. Playing a central role in optimizing organizationwide product development processes, LGE engineers use the portal to gain critical knowledge for generating and analyzing simulations, enhancing designs, and delivering leading-edge mobile devices, home entertainment and appliance products to customers faster. Ansys Learning Hub is a comprehensive on-demand knowledge portal led by Ansys experts that offers rich, structured resources and a programmatic, continuous learning curriculum for Ansys customers.

Ansys Accelerates Private Safety System

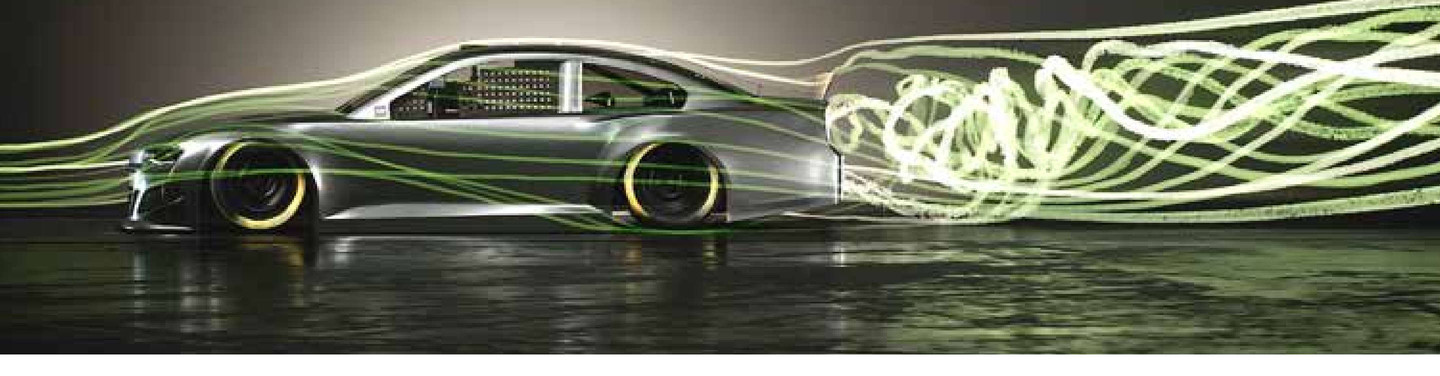
AMN July 2020

Together with its European channel partner DYNAmore, Ansys is supplying the BMW Group with Ansys LS-DYNA for passive safety system development in the next generation of safe, high-performance vehicles. Ansys LS-DYNA empowers users to optimize the design and analysis of passive safety systems — supporting more accurate predictions of vehicle behavior during collisions.

D2H Advanced Technologies and Ansys Speed NASCAR Race Car Development

October 2020

NASCAR racing teams are leveraging a state-of-the-art automated simulation workflow created by D2H Advanced Technologies (D2H) and Ansys to improve high-performance stock cars that are engineered with speed, efficiency and affordability. Through this collaboration, D2H and Ansys are significantly streamlining the development and improving the aerodynamics of race cars by enabling teams to nearly eliminate wind tunnel testing.



Ansys and Air Race E Pioneer Next-Generation Electric Aircraft

July 2020

Engineering teams are developing cleaner, faster and highly advanced electric aircraft using simulation solutions. Through a new sponsorship with Air Race E, Ansys technologies will help accelerate the design of innovative all-electric race planes competing in the 2021 Air Race E World Championship, a series of international air racing competitions that are spurring the future technology developments needed to drive more sustainable aviation.

Cummins Uses Ansys' Digital Transformation Technologies in R&D of Advanced Diesel Engines

October 2020

Through the collaboration, Cummins will leverage Ansys' tools and next-generation simulation process and data management (SPDM) platform to expedite the development of innovative, sustainable engines — significantly maximizing torque and horsepower, enhancing thermal efficiency and improving fuel economy, resulting in significant customer savings and reduced greenhouse gas emissions.

Ansys Releases On-Demand Content from its IDEAS Digital Forum

PR Newswire October 2020

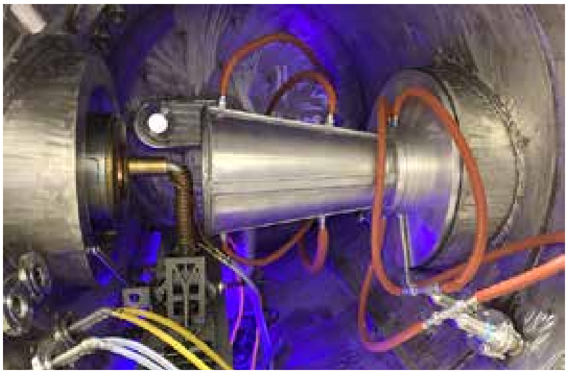
The two-day global event featured thought leadership keynotes and presentations from industry leaders at Arm, TSMC, Ericsson and more, along with technology sessions and product updates.

The IDEAS Digital Forum content explored the importance of simulation to analyze and optimize integrated circuit (IC) power, performance and reliability. Keynote and workshop speakers discussed how using high-fidelity analysis solutions save designers time and increase efficiency through better estimations early in the design process.

University of Texas at Arlington and Ansys Accelerate High-Speed Hypersonics Research and Development

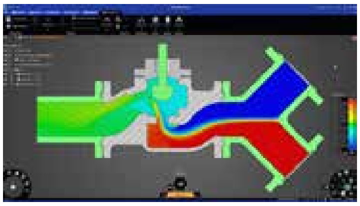
September 2020

The University of Texas at Arlington (UTA) and Ansys are developing an advanced design and analysis workflow for validating system models in the U.S. government's current and next-generation hypersonic vehicles. The workflow will fast-track certification of simulation software codes, help decrease hypersonic technology development spending and increase engineering productivity.



Ansys Discovery Greatly Improves the Product Design Process

July 2020



Ansys is helping engineering teams deliver significant gains in productivity, spur innovation and speed time to market with the new Ansys Discovery. Significantly expanding on the breakthrough advancements delivered by Ansys Discovery Live, this next-generation application delivers a comprehensive solution that combines interactive real-time simulation, high-fidelity Ansys solver technology and direct modeling in a single tool — powering cross-team collaboration to cost-effectively develop high-quality products.